554

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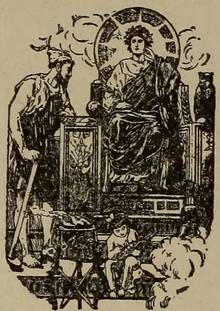

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# Cassier's Magazine

## An Engineering Monthly

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# INDEX TO VOLUME XL

FEB 27 1912

PAGE
Accident on the U. S. S. Delaware, The Boiler, . . . 94
Acetylene Welding and Cutting Machine, . . . 564
Illustrated.
Aerial Tramway of the Balaklala Consolidated Copper Co., William Hewitt, . . . 377
Illustrated.
Allen, Horace: Power Transmission in Gas Engines, . . . 511
Illustrated.
Allen, Percy R.: The Possibilities of the Internal Combustion Engine Applied to Marine Propulsion, . . . 705
Illustrated.
Alternating Stress Testing Machines, . . . C. A. M. Smith, . . . 422
Illustrated.
American Navy, The Development of the, . . . 766
Illustrated.
Ashley, F.: Technical Literature, . . . 174
Ashford, P. C.: Superheated Steam at Sea, . . . 638
Illustrated.
Automatic Train-Stopping Devices, . . . 92
Illustrated.
Balaklala Consolidated Copper Co., Aerial Tramway of, William Hewitt, . . . 377
Illustrated.
Balancing the Rotors of Turbo-Generators, . . . J. W. Rogers, . . . 318
Illustrated.
Batey, John: Live Steam Heating of Feed Water, . . . 541
BIOGRAPHICAL SKETCHES:
  Bolton, Reginald Pelham, . . . 385
  Campbell, Angus, . . . 1
  Fuller, George Ward, . . . 193
  Herr, Edwin M., . . . 481
  Holmes, Joseph Austin, . . . 97
  Jeffrey, Joseph A., . . . 673
  Whistler, Major George Washington, . . . 289
  Williston, Prof. Arthur Lyman, . . . 577
Boiler Accident on the U. S. S. Delaware, . . . 94
Boiler Feed-Water, The Purification of, . . . 561
Illustrated.
Booth, W. H.: The Driving of Cotton Mills, . . . 291
Illustrated.
Booth, W. H.: The Condensation of Steam, . . . 173
Booth, W. H.: Venezuela, . . . 226
Illustrated.
Brakes, Engine Testing, . . . W. D. Wansbrough, . . . 410
Illustrated.
Brazil Railways, The:
  Railways of the Rio Grande do Sul, XIV, . . . Lionel Wiener, . . . 17
  Illustrated.
  General Review and Conclusions, XV, . . . Lionel Wiener, . . . 149
  Illustrated.
Brewer, Chas. B.: Models of Vessels, . . . 40
Illustrated.
Brühl, Paul T.: The Corrosion of Brass Condenser Tubes, . . . 668
Burroughs, Wilbur Greeley: The Formation of Petroleum Accumulations, . . . 597
Illustrated.
Canal and Railway, The Transportation Cost by, . . . 761
Canal Locks, The Panama and Erie—A Contrast, . . . Day Allen Willey, . . . 693
Illustrated.
Catskill Aqueduct, The, I, . . . J. F. Springer, . . . 252
  Operative Conditions, II, . . . J. F. Springer, . . . 323
  Equipment and Methods of Work, III, . . . J. F. Springer, . . . 437
  Illustrated.
Chemistry and Engineering, The Relations of, . . . John B. C. Kershaw, . . . 545
Chemistry, The Earning Power of, . . . Arthur D. Little, . . . 465

PAGE
Coal, Washing and Sorting of Small, . . . . . . N. T. Williams, . . . 606
Illustrated.
Colles, George W.: The Future of Copper, . . . . . . . . . . . . 461
Colliery Explosions and Their Causes, . . . . . . Percy W. Taylor, . . . 244
Illustrated.
Comfort at Sea, The Organization of, . . . . . . Alwyn Waters, . . . 657
Illustrated.
Compass, The Gyro- . . . . . . . . . . A. C. Fredericks, . . . 515
Illustrated.
Condensation of Steam, . . . . . . . . . W. H. Booth, . . . 172
Continuous Vertical Transportation, . . . . . . J. F. Springer, . . . 163
Illustrated.
Copper, The Future of, . . . . . . . . . George W. Colles, . . 461
Corrosion of Brass Condenser Tubes, . . . . . . Paul T. Brühl, . . . 668
Cotton Mills, The Driving of, . . . . . . . W. H. Booth, . . . 291
Illustrated.
Crawford, H. M.: Mechanical Appliances for Dust Extraction in Cotton Mills, . . 579
Illustrated.
Diagnosing an Industrial Disease:
  Methods of Reducing Congestion, III, . . . . . H. F. J. Porter, . . . 81
  Factory Fire Drills, IV, . . . . . . . . H. F. J. Porter, . . . 177
Illustrated.
Diesel Motor in America, . . . . . . . . . . . . . . . . . 190
Dominian, Leon: The Railway Situation in Turkey, . . . . . . . . . 195
Illustrated.
Dooley, William H.: Engineering Methods in Germany and America, . . . . 61
Driving of Cotton Mills, . . . . . . . . . . W. H. Booth, . . . 291
Illustrated.
Dust Extraction in Cotton Mills, Mechanical Appliances for, H. M. Crawford, . . . 579
Illustrated.
Earning Power of Chemistry, . . . . . . . . Arthur D. Little, . . . 465
Efficiency, A Study in Machinery, . . . . . . . . . . . . . 570
Efficiency in Fuel Combustion, . . . . . . . H. M. Wilson, . . . 652
Efficiency in Its Relation to the Consumer, . . . . . H. F. Stimpson, . . . 313
Electric Driving for Mule Spinning, . . . . . . Albert Walton, . . . 629
Illustrated.
Electricity in Mines, New British Rules for the Use of, . . . . . . . . 356
Electric Railways, Suspended, for Industrial Service, . J. F. Gairns, . . . . 498
Encyclopædia, The Engineer and the, . . . . . . H. H. Suplee, . . . 753
Engine-Testing Brakes, . . . . . . . . . . W. D. Wansbrough, . . 410
Illustrated.
Engineer and the Encyclopædia, . . . . . . . H. H. Suplee, . . . 753
Engineering Methods in Germany and America, . . . William H. Dooley, . . 61
Explosions, Colliery, and Their Causes, . . . . . Percy W. Taylor, . . . 244
Illustrated.
Evolution of the Geared Locomotive, . . . . . . William Fletcher, . . . 430
Illustrated.
Feed Water, Live Steam Heating of, . . . . . . John Batey, . . . . 541
Feed Water, The Purification of Boiler, . . . . . . . . . . . . 561
Illustrated.
Fernald, R. H.: Gas Power from Low Grade Fuels, . . . . . . . . . 572
  Fuel Resources of the United States, . . . . . . . . . . . . 85
Illustrated.
Fletcher, William: The Evolution of the Geared Locomotive, . . . . . . . 430
Illustrated.
Fredericks, A. C.: The Gyro-Compass, . . . . . . . . . . . . . 515
Illustrated.
Fuel Combustion, Efficiency in, . . . . . . . H. M. Wilson, . . . 652
Fuel Resources of the United States, . . . . . . Robert H. Fernald, . . 85
Illustrated.
Fuel Supply, Liquid, . . . . . . . . . . Henry Hale, . . . . 3
Illustrated.
Future of Copper, The, . . . . . . . . . George W. Colles, . . 461
Future Sources of Motive Power, . . . . . . . Wm. Ramsay, . . . 550
Gairns, J. F.: Remarkable Locomotives of 1911, . . . . . . . . . . 99
Illustrated.
  Suspended Electric Railways for Industrial Service, . . . . . . . . . 498
Illustrated.

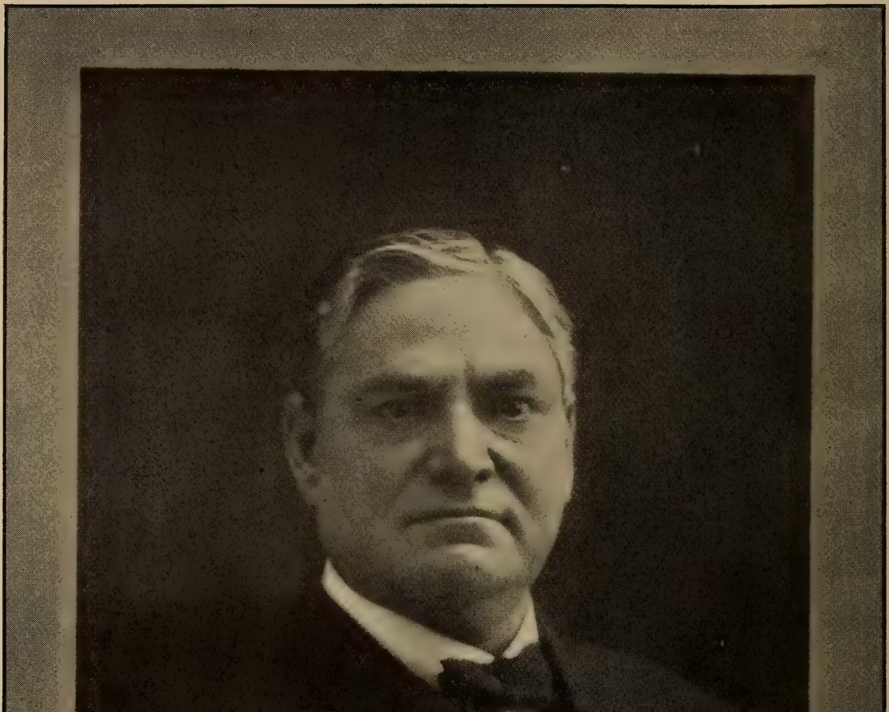
PAGE
Gas Engines, Power Transmission in, Horace Allen, 511
Illustrated.
Gas Power from Low Grade Fuels, R. H. Fernald, 572
Geared Locomotives, The Evolution of the, William Fletcher, 430
Illustrated.
Germany and America, Engineering Methods in, William H. Dooley, 61
Great City, The Water Supply of a, I, J. F. Springer, 252
Illustrated.
Operative Conditions, II, J. F. Springer, 323
Illustrated.
Equipment and Methods of Work, III, J. F. Springer, 437
Illustrated.
Great Falls Hydraulic Power Plant, M. Hebgen, 273
Illustrated.
Great Transformation:
I, The Freedom of the Air, H. H. Suplee, 55
II, The Transformation in Commerce, H. H. Suplee, 123
III, The Transformation in Warfare, H. H. Suplee, 219
IV, The Transformation in Architecture, H. H. Suplee, 345
V, The Transformation in Government, H. H. Suplee, 416
VI, The Transformation in Daily Life, H. H. Suplee, 529
VII, Aviation and Exploration, H. H. Suplee, 648
Great Water Power Sites, Henry Hale, 387
Illustrated.
Greenfield, B. S.: Human Energy as a Motive Power, 502
Illustrated.
Gyro-Compass, The, A. C. Fredericks, 515
Illustrated.
Hale, Henry: Liquid Fuel Supply, 3
Illustrated.
Great Water Power Sites, 387
Illustrated.
Hall, W. M., and H. Maxwell: Longleaf Pine—A Great Structural Timber, 661
Hebgen, M.: The Great Falls Hydraulic Power Plant, 273
Illustrated.
Hewitt, William: Aerial Tramway of the Balaklala Consolidated Copper Company, 377
Illustrated.
Heyland's Vector Diagram for Testing Induction Motors, The Application of, J. W. Rogers, 70
Illustrated.
Human Energy as a Motive Power, B. S. Greenfield, 502
Illustrated.
Hydraulic Power Plant, The Great Falls, M. Hebgen, 273
Illustrated.
Indicator Springs, Determining the Accuracy of, E. K. Uebe, 91
Illustrated.
Internal-Combustion Engine Applied to Marine Propulsion, The Possibilities of the, Percy R. Allen, 705
Illustrated.
Impact Testing, Methods of, C. A. M. Smith, 155
Illustrated.
Johnson, F. T.: Large Steam Laundries, 351
Kershaw, John B. C.: The Relations of Chemistry and Engineering, 545
Knorr, Karl W.: Notes on the Reduction of Power Losses, 369
Illustrated.
Large Steam Laundries, F. T. Johnson, 351
Laws, B. C.: Stability of Ships, 360
Illustrated.
Little, Arthur D.: The Earning Power of Chemistry, 465
Liquid Fuel Supply, Henry Hale, 3
Illustrated.
Liverpool, The Port of, Mark Meredith, 206
Illustrated.
Live Steam-Heating of Feed Water, John Batey, 541
Locomotive, The Evolution of the Geared, William Fletcher, 430
Illustrated.
Locomotives of 1910, Remarkable, J. F. Gairns, 99
Illustrated.

PAGE
Longleaf Pine—A Great Structural Timber, W. M. Hall and H. Maxwell, 661
Low Grade Fuels, Gas Power from, R. H. Fernald, 572
Machine, Acetylene Welding and Cutting, 564
Illustrated.
Machinery Efficiency, A Study in, 570
Machines, Alternating Stress Testing, C. A. M. Smith, 422
Illustrated.
Magnetic Ore Dressing, R. Cyril V. Whitfield, 533
Illustrated.
Marine Steam Turbine, The, Chas. A. Parsons, 685
Illustrated.
Maxwell, H., and W. M. Hall: Longleaf Pine—A Great Structural Timber, 661
Mechanical Appliances for Dust Extraction in Cotton Mills, H. M. Crawford, 579
Illustrated.
Meredith, Mark, The Port of Liverpool, 206
Illustrated.
Methods of Engineering in Germany and America, William H. Dooley, 61
Methods of Impact Testing, C. A. Smith, 155
Illustrated.
Methods of Stone Quarrying, Albert Wilhelm, 129
Illustrated.
Mills, James Cooke: The New Ship Canal and Locks at Sault Sainte Marie, 675
Illustrated.
Mining Industry and the Public Lands, George Otis Smith, 476
Models of Vessels, Chas. B. Brewer, 40
Illustrated.
Montgomerie, J.: The Arrangement and Construction of Oil Vessels, 737
Illustrated.
Motive Power, Human Energy as a, B. S. Greenfield, 502
Illustrated.
Motive Power, Future Sources of, Wm. Ramsay, 550
Motor in America, The Diesel, 190
Motor, Diesel in America, 190
Mule Spinning, Electric Driving for, Albert Walton, 629
Illustrated.
Navy, The American, 766
Illustrated.
Oil Vessels, The Arrangement and Construction of, J. Montgomerie, 737
Illustrated.
Ore Dressing, Magnetic, R. Cyril V. Whitfield, 533
Illustrated.
Organization of Comfort at Sea, Alwyn Waters, 657
Illustrated.
Panama and Erie Canal Locks—A Contrast, Day Allen Willey, 693
Illustrated.
Parsons, Charles A.: The Marine Steam Turbine, 687
Illustrated.
Petroleum Accumulations, The Formation of, Wilbur Greeley Burroughs, 597
Plant, The Great Falls Hydraulic Power, M. Hebgen, 273
Illustrated.
Port of Liverpool, Mark Meredith, 206
Illustrated.
Porter, H. F. J.: Diagnosing an Industrial Disease.
  III.—Methods of Reducing Congestion, 81
  IV.—Factory Fire Drills, 177
Illustrated.
PORTRAITS:
  Bolton, Reginald Pelham, 385
  Campbell, Angus, 2
  Fuller, George Ward, 194
  Herr, Edwin M., 482
  Holmes, Joseph Austin, 97
  Jeffrey, Joseph A., 674
  Whistler, Major George Washington, 290
  Williston, Prof. Arthur Lyman, 578
Possibilities of the Internal Combustion Engine Applied to Marine Propulsion, Percy R. Allen, 705
Illustrated.

PAGE
Power Losses Reduction of, . . . . . . . . Karl W. Knorr, . . . 369
Illustrated.
Power Transmission in Gas Engines, . . . . . . Horace Allen, . . . 511
Illustrated.
Public Lands, The Mining Industry and the, . . . George Otis Smith, . . 476
Public, The Railways and the, . . . . . . . Howard Elliott, . . . 567
Purification of Boiler Feed-Water, . . . . . . . . . . . . . . . 561
Illustrated.
Railway Situation in Turkey, . . . . . . . Leon Dominian, . . . 195
Illustrated.
Railway, The Transportation Cost by Canal and, . . . . . . . . . . 761
Railways and the Public, . . . . . . . Howard Elliott, . . . 567
Railways of Brazil:
  XIV.—Railways of the Rio Grande do Sul, . . . Lionel Wiener, . . . 17
  Illustrated.
  XV.—General Review and Conclusions, . . . Lionel Wiener, . . . 149
Railways, Suspended Electric, for Industrial Service, . J. F. Gairns, . . . . 498
Illustrated.
Reduction of Power Losses, . . . . . . . . Karl W. Knorr, . . . 369
Illustrated.
Relations of Chemistry and Engineering. . . . . John B. C. Kershaw, . . 545
Ramsay, Sir Wm.: Future Sources of Motive Power, . . . . . . . . . 550
Remarkable Locomotives of 1910, . . . . . . J. F. Gairns, . . . . 99
Illustrated.
Requisites for Success, . . . . . . . . . J. Harvey Dew, . . . . 374
Resources of the United States, Fuel, . . . . . Robert H. Fernald, . . 85
Illustrated.
Rogers, J. W.: Balancing the Rotors of Turbo-Generators, . . . . . . . . . 318
Illustrated.
Sault Sainte Marie, The New Ship Canal and Locks at, . James Cooke Mills, . . 675
Illustrated.
Ships, Stability of, . . . . . . . . . . . B. C. Laws, . . . . 360
Illustrated.
Small Coal, Washing and Sorting of, . . . . . . N. T. Williams, . . . 606
Illustrated.
Smith, C. A. M.: Alternating Stress Testing Machines, . . . . . . . . . 422
Illustrated.
Smith, C. A. M.: Methods of Impact Testing, . . . . . . . . . . . . 155
Illustrated.
Smith, George Otis: The Mining Industry and the Public Lands, . . . . . . 476
Sources of Motive Power, Future, . . . . . . . Wm. Ramsay, . . . 550
Springer, J. F.: Water Supply of a Great City, . . . . . . . . . . . 252
Illustrated.
  The Water Supply of a Great City, II. Operative Conditions, . . . . . . 323
  Illustrated.
  The Water Supply of a Great City, III. Equipment and Methods of Work, . . 437
  Illustrated.
  Titanium Steel, . . . . . . . . . . . . . . . . . 483
  Illustrated.
Stability of Ships, . . . . . . . . . . B. C. Laws, . . . . 360
Illustrated.
Steam, Condensation of, . . . . . . . . . W. H. Booth, . . . 172
Steam Laundries, Large, . . . . . . . . F. T. Johnson, . . . 351
Steel, Titanium, . . . . . . . . . . . J. F. Springer, . . . 483
Illustrated.
Stimpson, H. F.: Efficiency in its Relation to the Consumer, . . . . . . . 313
Stone Quarrying, Methods of, . . . . . . . Albert Wilhelm, . . . 129
Illustrated.
Success, The Requisites for, . . . . . . . . J. Harvey Dew, . . . 374
Superheated Steam at Sea, . . . . . . . . P. C. Ashford, . . . 638
Illustrated.
Suplee, Henry Harrison.: The Engineer and the Encyclopædia, . . . . . . . 753
  The Great Transformation. I., Freedom of the Air, . . . . . . . . . 55
  The Great Transformation. II., Transformation in Commerce, . . . . . . 123
  Illustrated.
  The Great Transformation. III., The Transformation in Warfare, . . . . . 219
  Illustrated.
  The Great Transformation. IV., The Transformation in Architecture, . . . 345

PAGE
Suplee, Henry Harrison.:
  The Great Transformation. V., The Transformation in Government, 416
  The Great Transformation. VI., The Transformation in Daily Life, 529
  The Great Transformation. VII., Aviation and Exploration, 648
Suspended Electric Railways for Industrial Service, J. F. Gairns, 498
  Illustrated.
Taylor, Percy W.: Colliery Explosions and Their Causes, 244
  Illustrated.
Technical Literature, F. Ashley, 174
Timber, Longleaf Pine, A Great Structural, W. M. Hall and H. Maxwell, 661
Testing Induction Motors, The Application of Heyland's Vector Diagram for, J. W. Rogers, 70
  Illustrated.
Titanium Steel, J. F. Springer, 483
  Illustrated.
Train-Stopping Devices, Automatic, 92
  Illustrated.
Transportation Costs by Canal and Railway, 761
Transportation, Continuous Vertical, J. F. Springer, 163
  Illustrated.
Tubes, The Corrosion of Brass Condenser, Paul T. Brühl, 668
Turbine, The Marine Steam, Chas. A. Parsons, 687
  Illustrated.
Turbo-Generators, Balancing the Rotors of, J. W. Rogers, 318
  Illustrated.
Turkey, The Railway Situation in, Leon Dominian, 195
  Illustrated.
Uebe, E. K.: Determining the Accuracy of Indicator Springs, 90
  Illustrated.
Venezuela, W. H. Booth, 226
  Illustrated.
Vertical Transportation, Continuous, J. F. Springer, 163
  Illustrated.
Vessels, Models of, Chas. B. Brewer, 40
  Illustrated.
Walton, Albert: Electric Driving for Mule Spinning, 629
  Illustrated.
Waters, Alwyn: The Organization of Comfort at Sea, 657
  Illustrated.
Wansbrough, W. D.: Engine-Testing Brakes, 410
  Illustrated.
Washing and Sorting of Small Coal, N. T. Williams, 606
  Illustrated.
Water Power Sites, Great, Henry Hale, 387
  Illustrated.
Water Supply of a Great City, I., J. F. Springer, 252
  Illustrated.
  II., Operative Conditions, J. F. Springer, 323
  Illustrated.
  III., Equipment and Methods uf Work, J. F. Springer, 437
  Illustrated.
Wiener, Lionel: The Railways of Brazil.
  XIV., Railways of Rio Grande do Sul, 17
  Illustrated.
  XV., General Review and Conclusion, 149
Wilhelm, Albert: Methods of Stone Quarrying, 129
  Illustrated.
Willey, Day Allen: The Panama and Erie Canal Locks—A Contrast, 603
  Illustrated.
Williams, N. T.: Washing and Sorting of Small Coal, 606
  Illustrated.
Wilson, H. M.: Efficiency in Fuel Combustion, 652
Whitfield, R. Cyril V.: Magnetic Ore Dressing, 533
  Illustrated.

Mr. Angus Campbell, whose portrait we give in this issue, is an example of the value of independent observation and ingenuity in a line of work in which the force of routine may be said to have impeded real development. Nearly every industry has its limitations. Until the invention of the cotton gin by Eli Whitney the limit of the useful cotton crop was the rate at which human fingers could remove the seeds from the boll. The limitation of the seeds being removed, the extent of the useful crop in the Southern United States has reached 10,000,000 to 12,000,000 bales a year. Since the ground is capable of producing more than twice this amount, the limit appears in the capacity of the available labor to pick the cotton. Mr. Campbell, originally a pattern maker living in Chicago, visited Texas, and, seeing the problem on the spot, was stimulated to devise a machine which can pick more than 6,400 pounds, or twelve bales, of cotton a day, being the work of thirty skilled pickers.



ANGUS CAMPBELL.

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INDEXED.

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AN ENGINEERING MONTHLY

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## LIQUID-FUEL SUPPLY

### DEVELOPMENTS IN THE OIL FIELDS OF THE WESTERN UNITED STATES

**By Henry Hale**

In a recent issue of this magazine there was described the latest progress in the construction of internal combustion engines for use with oil fuel. The extending employment of motors, not only for the heavy oils, but also for use with the lighter hydrocarbon derivatives of petroleum, lends especial interest to all that relates to the sources of supply. Of these sources, there are two of dominating importance—one in the United States and one in Southeastern Russia. The present article relates especially to the more recent developments in America, and will give some idea of the opportunities for intelligent conservation which existed in connection with the utilization of this great natural resource.—The Editor.

THE fact that Western Pennsylvania lay over a submarine lake of petroleum was not known until Edwin L. Drake drilled a hole through the rock and sand near the town of Titusville. Drake was familiar with the geological formation, and had found the oil coating the water of a farm well near where he made his boring. At 70 feet a "pocket" of oil was struck which oozed to the surface. But the reservoir from which it came was about 500 feet deeper, and when this was reached the oil spouted into the air through the bore hole.

In the half-century since the first well was opened petroleum has been pumped from such an area of the country which is underlaid with oil that at the present time the United States supplies more than one-half of the petroleum consumed in the world as fuel, for lighting and for other purposes. This is largely due to the discovery of the extensive deposits of oil in the country west of the Mississippi river.

The development of the oil resources in the West has been so recent that its importance has not as yet been appreciated. Many are still accustomed to think of Western Pennsylvania as the locality from which the bulk of the oil comes, but several years ago the rank of Pennsylvania as an oil producer was greatly reduced, until at the present time it is exceeded by five other States in the yield of this resource. At the present time the combined wells of the United States are yielding no less than 200 million barrels of oil.

Since 1900 such has been the expansion of the industry in this country that the production is now nearly four times that of 1900. This is

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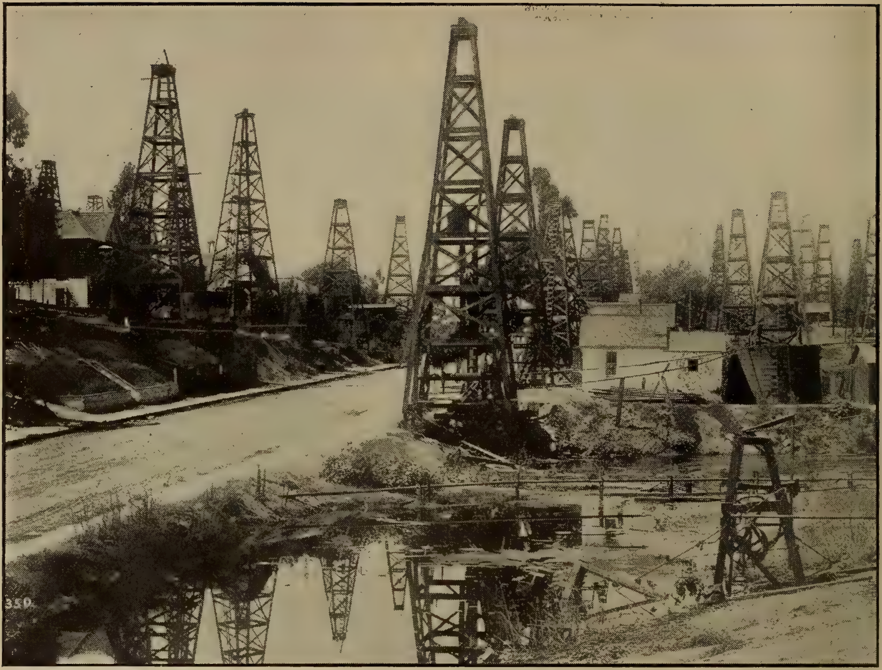


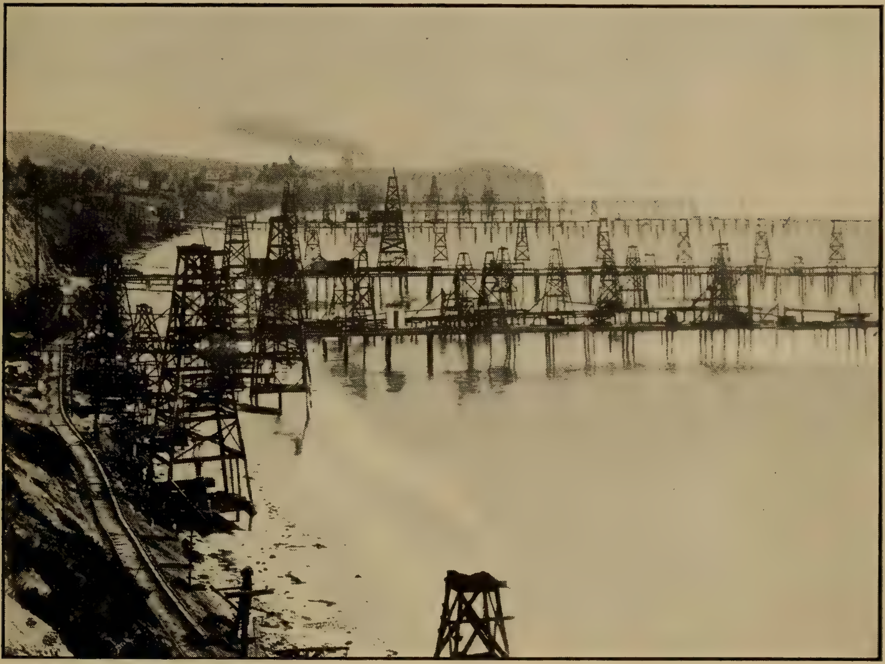
OIL WELLS IN A FORMER RESIDENCE SECTION OF LOS ANGELES, CALIFORNIA

shown by the increase in the quantity of petroleum secured from larger producing districts. What is known as the Gulf and Caddo district, comprising Louisiana and Texas, yielded 14 million barrels in 1910, compared with only 1 million barrels in 1900. Illinois equals the States of Pennsylvania, Ohio, Indiana and West Virginia, with an output of 32 million barrels; but by far the greatest production is now coming from what is termed the mid-continent and Rocky Mountain field. This comprises all the wells in the territory extending westward from Oklahoma and Kansas to the Rocky Mountains. It produced no less than 53 million barrels in 1910. California's oil fields, however, are so greatly developed that its record for the last calendar year was 73 million barrels, more than twice the combined output of the older Eastern fields. The statistics show that the wells west of the Mississippi river are now yielding the bulk of the American petroleum supply, nearly 150 million barrels in 1910, out of a total of 204 million barrels, as estimated by the United States Geological Survey. How rapidly the petroleum industry has developed may be shown by the fact that the entire output in 1900 was but 57 million barrels and in 1908, 166 million barrels. The figures are a proof of the great extent of this natural resource.

During the year of 1892 the development of the Texas and California oil districts began on a large scale. The Newhall district, as it is called in California, is located in the suburbs of the city of Los Angeles. In one year from the time petroleum was found in this district, in 1892, it was producing 100,000 barrels. Investigation showed that deposits of the liquid existed under various portions of the State, even beneath the ocean, and the development was so rapid that California now furnishes over a third of the petroleum secured from this country.

Patillo Higgins, a country school teacher in eastern Texas, conceived the idea that he could make more money out of oil than in the classroom. He succeeded in organizing a company to prospect, but nearly ten years elapsed before he secured enough money to bore the well. When it began flowing at the rate of 50,000 barrels every twenty-four hours people who had laughed at the visionary scheme changed their minds. This was the first of the famous "gushers."

Higgins put down his well on the prairies a few miles from Beaumont, Tex. Within thirty days seven more "rigs" in sight of it had reached the sands, and were each spouting up from 10,000 to 20,000 barrels daily. Not strange, is it, that in two months 400 companies had been organized to bore for oil, to sell land, to deal in oil machinery, and to build refineries and pipe lines? The history of Oil City was repeated in and about Beaumont. The story of "Coal Oil Johnny" had hundreds of sequels in Texas; for, within eighteen months from the beginning of the boom, it had collapsed to such an extent that 750 derricks planted over "dry holes" in the Spindle Top district were standing deserted, and not over 100,000 barrels were being pumped daily from the wells in operation. This was what the prospectors had to show for an actual investment of fully $10,000,000. But it was only another case of overdoing the matter. True, no longer do you see the wells throwing the fluid hundreds of feet in the air; but the noise of the pumps is still heard on Spindle Top, for it has never given out, and today is producing at the rate of nearly two million barrels annually.



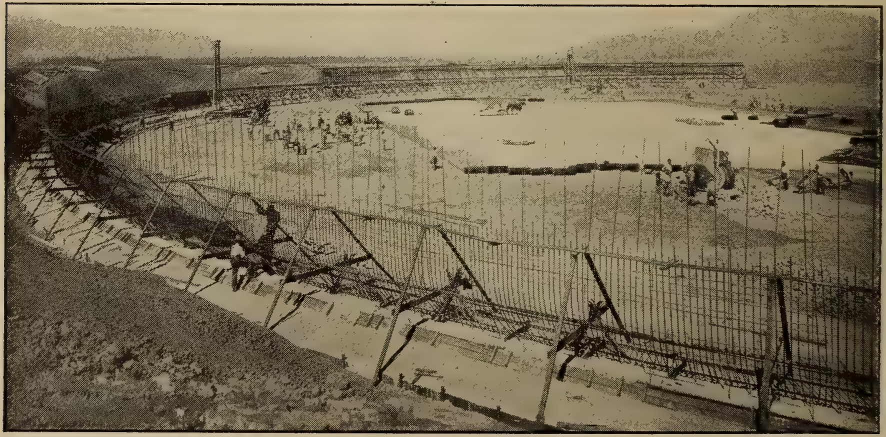
PUMPING OIL FROM UNDER THE PACIFIC OCEAN

This bit of history is worth repeating, since it resulted in the great majority of the prospectors deserting Spindle Top. Some had the idea that it was worth while to bore elsewhere in the State, for a little oil had been previously found outside of the Spin-

CLEARING THE GROUND FOR THE CONCRETE OIL TANK AT SAN LUIS OBISPO, CALIFORNIA

dle Top field. It was noticed that the surface of a small pond called Sour Lake—because it was fed by mineral springs—was occasionally discolored with oil. The test drill pierced its shore and another oil field was exploited. The Sour Lake boom followed that of Spindle Top. Tracts of pine forests were cut down and the timber put into the framework of derricks planted so closely together that they touched each other. A stretch of desolate prairie on the edge of the forest became a city of 10,000 people in two years. Land which had originally sold at $10 an acre sold for as many thousand. Sixteen acres of pine forest, known as the "shoestring" district, because of the long rows of rigs, were turned into money to the extent of $75,000. One tract of 850 acres in this field sold for $900,000 before a single hole had been made in it.

Following Sour Lake field came Saratoga, then Batson—all located within thirty miles of the original gusher. Then the diggers penetrated still another deposit within sight of the little town of Humble. Not a barrel of oil came from it until February, 1905. Since the first discoveries five fields have been developed in Texas alone; but Louisiana is also a contributor, for the prairie skirting the Gulf of Mexico not only rests



THE STEEL REINFORCEMENT OF THE CONCRETE RESERVOIR

BUILDING THE CONCRETE WALLS OF THE RESERVOIR AT SAN LUIS OBISPO

upon an inland sea, which is used to irrigate its great rice fields, but is underlaid with lakes of oil, from which a million barrels monthly are being taken, making a petroleum-bearing territory in the two States of 250 miles from east to west.

The activity of the industry in California is shown by the fact that, since oil was pumped from the ground on which the city of Los Angeles stands, important deposits have been found, not only in Los Angeles county, but in Ventura, Santa Barbara, Kern, King and Fresno. The activity in Kern has assumed very large proportions. In 1905 Kern county contributed fully 20,000,000 barrels of the California output; but the supply which exists in the original field is such that over 1,000 wells have already been bored in Los Angeles county, and this number will be considerably increased during the present year.

The latest petroleum discovery in the United States has also been made in Southern California, about 100 miles from the little town of San Luis Obispo. It is termed the Sunset field. When the first boring showed the existence of the oil in large quantities the operators decided to have storage facilities before other

THE GREAT REINFORCED CONCRETE OIL TANK NEAR SAN LUIS OBISPO, BEFORE THE ROOF WAS PUT ON, CAPACITY, 1,000,000 BARRELS

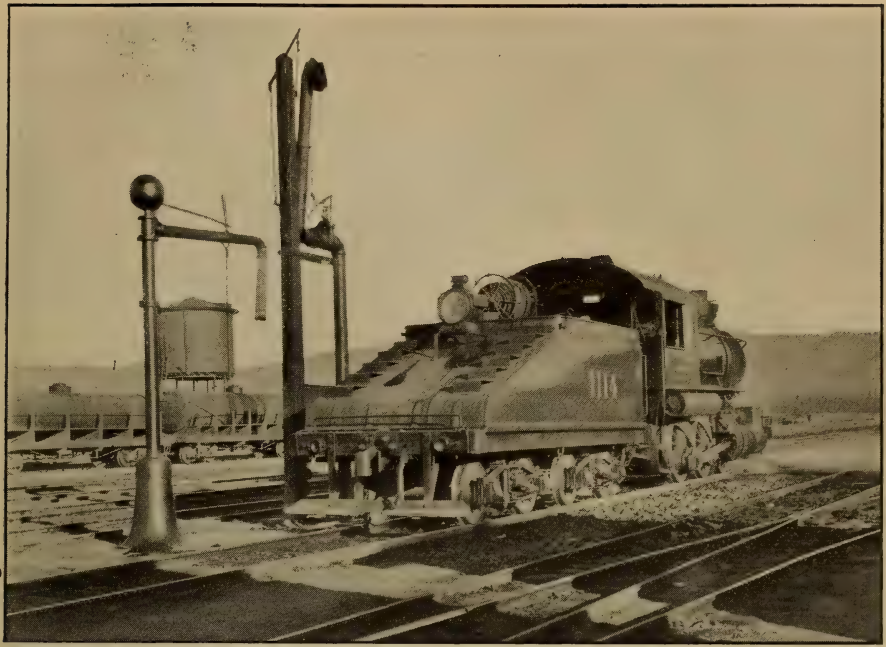
OIL FLOWING THROUGH AN OPEN DITCH IN TEXAS

wells were opened. Two concrete circular reservoirs were constructed near San Luis Obispo, which are the largest petroleum holders in America. They are uniform in size, and each covers no less than 6½ acres of ground, having a capacity of 1,000,000 barrels.

In the construction of this "Tank Farm," as the group of reservoirs is termed, some very interesting engineering plans have been carried out to insure the necessary strength to withstand the great lateral pressure and to give durability of construction in each reservoir. The wall is a cantilever type of retaining barrier, built circular, with radius of 300 feet 3 inches. The wall stands free, without buttresses, is 20 feet high and 17 feet at base, covered by a wooden roof supported by posts which rest on concrete footings. The floor is 2½ inches thick, and slopes to the centre, where a sump is built with an outlet pipe for purposes of drainage. The sump is three feet lower than the base of the wall. The reinforcing is of plain round rods of iron ½ inch in diameter, distributed horizontally and vertically. The dirt taken from the hole was used to make a bank, or levee, surrounding the wall, as a protection against breakage or fire.

The contract price was $320,000 for the two reservoirs so far built, and it required five months to construct them. The walls are 6 inches thick at the top and 1 foot thick about 12 feet down, spreading from this point to 17 feet at base. The foundation is of clay, except in some places, where the clay lies below the lower profile of the wall. Here a sub-foundation of concrete is placed. This varies from 1½ to 2 feet in depth. These reservoirs were constructed for storage in an oil territory reached by a 100-mile pipe line, not for oil produced in the immediate vicinity, but it is piped from the Sunset and McKittrick. From the reservoirs the oil is then piped to Port San Luis, to the boats which carry oil for the Pacific markets. In addition to the two concrete reservoirs, thirty-six steel tanks, holding 55,000 barrels each, are being completed.

The immense quantity of petroleum has enabled it to be sold to consumers at such a low price that these discoveries in the West have been of much importance in the general development not only of Texas and adjacent country, but of the entire Southwestern United States, including the Pacific Coast. Naturally, the attention of the transportation companies and large manufacturers was attracted to the apparently abundant supply of oil in the Beaumont field, and, taking advantage of the low prices at which the operators were forced to sell the product, they experimented with its use on an elaborate scale. Nearly all of the railroad companies equipped some of their locomotives with oil-burning apparatus and compared the results attained with those from the soft coal which was used as engine fuel. The outcome of these experiments proved that from 3½ to 3 7/10 barrels of the ordinary Texas petroleum will evaporate as much water as a ton of the ordinary bituminous coal used in the



A LOCOMOTIVE TAKING OIL FUEL AND WATER AT A STATION ON SOUTHERN CALIFORNIA. THE OIL IS PIPED DIRECTLY TO THE TRACKS

Southwest, and that, at a cost of from 50 to 60 cents a barrel, the oil is fully 25 per cent. cheaper than the coal, considering the cost of its transportation from the nearest mines. But contracts were made to supply the oil in quantities as low as 25 and 30 cents per barrel, so that the transportation companies, in many instances, have probably reduced their fuel bills fully 50 per cent. by the substitution of oil. By its use the services of the fireman can often be dispensed with, as the engineer can regulate the supply by merely the pressure of the feed-valve, while, by converting the space used for coal into an oil tank, a far larger quantity of the fuel, heat units considered, can be carried in the tender than in the case of coal.

These advantages have more than made up the expense of equipping the engines with oil burners and tanks, the cost of which averages about $150 per locomotive. The general manager of the Southern Pacific Railway has announced that all of the locomotives of that road are to be converted into oil-burners, consuming California petroleum. This decision was reached after a trial made on the Western division with thirty-nine engines. They consumed 12,000 barrels of oil, at a cost of $3,600, which, it is estimated, was equal to 4,000 tons of coal, at a cost of $20,000, at the prices paid for this fuel on the Pacific Coast. This company has no less than 1,400 locomotives, so that its requirements alone would take a very large quantity from the Southwestern field; but the Atchison, Topeka & Santa Fé Company has about 200 locomotives using oil, and will utilize it on additional engines during the next year, as will also the Missouri, Kansas & Texas, the Missouri Pacific, and other companies of the country.

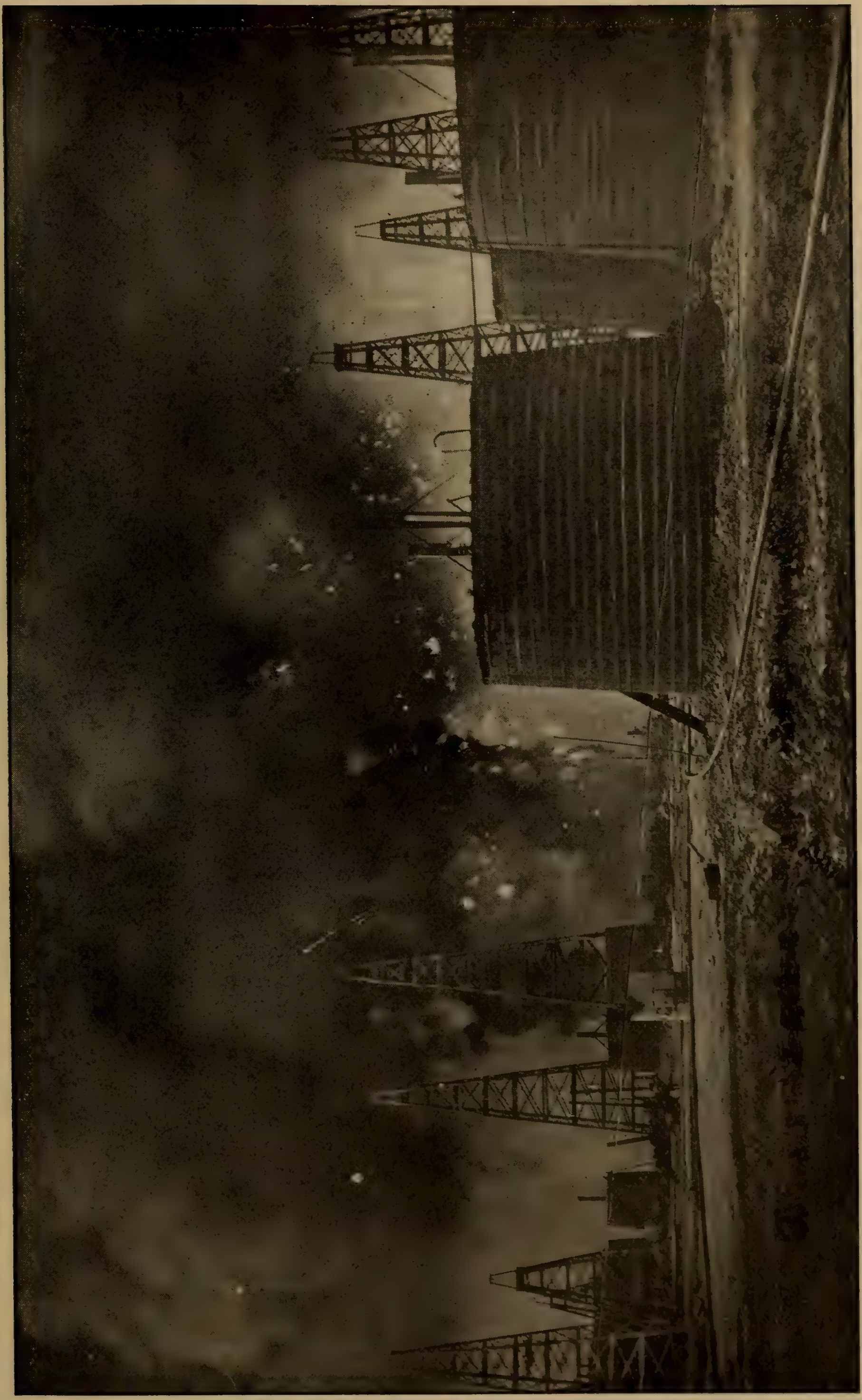
Experiments made in sugar refineries, as well as irrigation pumping plants, rice mills, and other industries, indicate that oil at 50 cents per barrel is more economical than soft coal, and the sale of oil-burning

OVERFLOWING OIL TANKS IN TEXAS. A PROLIFIC CAUSE OF FIRES

machinery has become so extensive in Louisiana and Texas that this section is now one of the principal markets of the world for such equipment. Incidentally, it might be said that locomotives have been built purposely for the burning of liquid fuel, and on these the services of the fireman are dispensed with. The oil is generally sprayed into the fire-box by a steam jet. The combustion is almost perfect, and waste of fuel is reduced to a minimum. For the purpose of convenience, however, the "briquette," in which the petroleum is held as a solid, is finding favour.

By mixing the oil in its crude state with certain chemicals the compound is converted into a mass, which, when subjected to a pressure ranging from 300 to 1,000 pounds to the square inch, becomes a solid substance, and can be handled like coal or wood. Tests which have been made with this compound show that a ton of it contains as many heat units as two tons of high-grade bituminous coal, such as the Welsh or Pocahontas varieties.

The economy of pipe lines from the fields to the seaboard has caused the investment of a large amount of capital in these conduits; but the producers have appreciated the value of storage facilities for keeping the market price at a profitable figure, and, as a result, a very large percentage of the output can be held in the fields should it be desired. Thus reservoir construction is an important industry in itself, for some of them are literally mammoth in proportions. The older reservoir usually is circular in form, the walls being composed mainly of the earth taken out in making the excavation. The interior, however, is covered with a lining, sometimes of wooden planking, each plank being dovetailed or tightly joined to the adjacent ones. A more durable structure, as already described, is lined with concrete. In fact, it is a great shell of the material, as the bottom is also covered



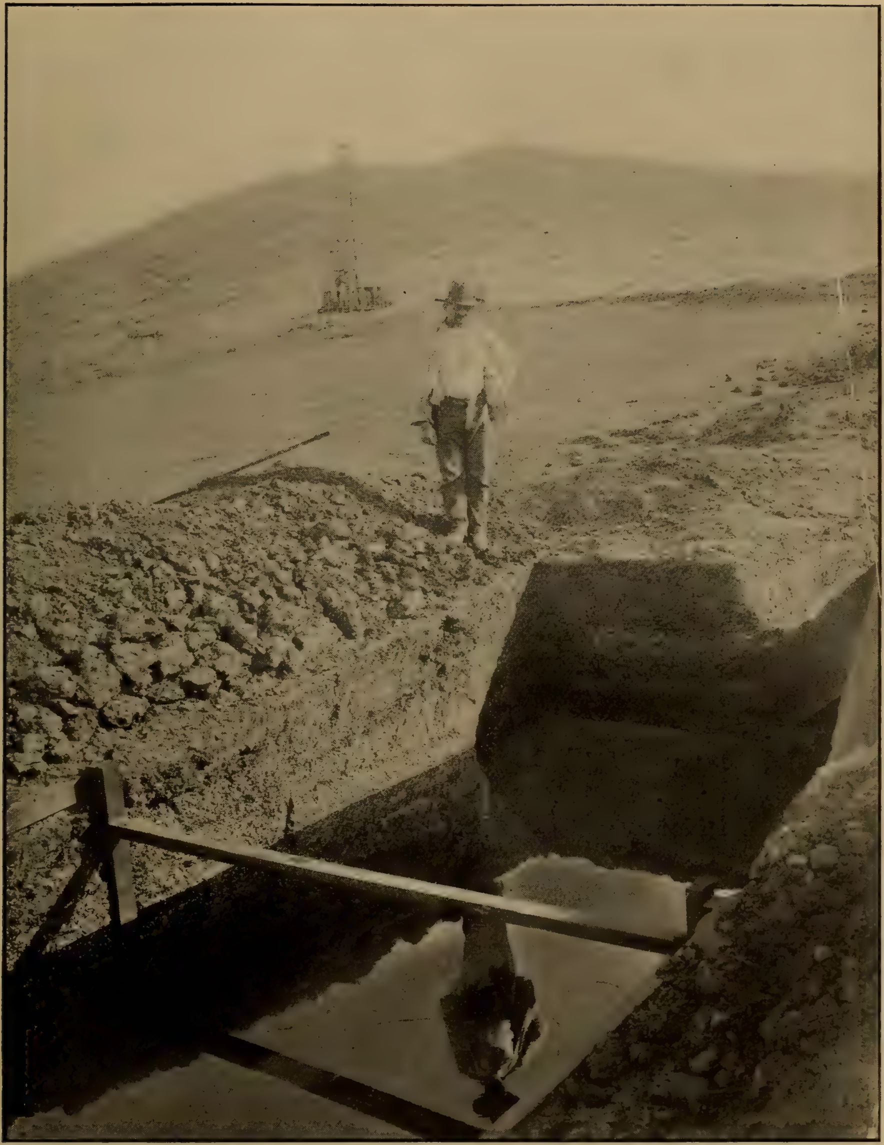
A FIRE CAUSED BY OVERFLOWING TANKS IN THE SPINDLE-TOP DISTRICT, TEXAS

A GROUP OF OIL WELLS OWNED BY A RAILROAD COMPANY

with it, openings only being provided for intake and discharge pipes. The top of the reservoir is covered over with wood, tin, sheet iron, or specially prepared roofing material, supported on a timber framework resting on the bottom or floor. The covering is not only essential to keep the oil free from dust and other impurities, but to protect it from rainfall. During periods of high temperature there is danger of ignition from direct exposure of the liquid to the sun's rays. Consequently, some such covering as asbestos is desirable, and this material is frequently utilized.

Many of the reservoirs are erected adjacent to the wells which they are to serve, the discharge pipe of each well being connected with them. As some of the reservoirs in the Bakersfield district of California can hold no less than 500,000 barrels, a single one will suffice for an extensive series of wells. The smaller tank is also utilized, being constructed both of wood and metal. In the Sour Lake field, in Texas, cypress is employed for this purpose, some of the single vats holding 25,000 barrels. The iron tank is of the usual design seen in the Eastern territory—cylindrical in shape. It is generally connected to a series of others by overhead or buried conduits.

While the oil of the Southwest is classed as petroleum, it has been used thus far for fuel and for lubrication. Consequently, it does not compete



UNCOVERING A POOL OF OIL IN CALIFORNIA

with the Pennsylvania oil, the bulk of which is utilized for illumination. A hundred gallons of the Pennsylvania oil can be converted into seventy-six gallons of illuminating oil of a fair grade, three gallons of lubricant and eleven of the naphtha grades, the quantity of actual waste averaging not over 5 per cent. as it comes from the wells. The Western refineries secure only about 20 per cent. of illuminating oil from the California and Texas varieties, while considerable of it is so impregnated with sulphur that it is necessary to distill the liquid a second time, increasing the expense of refining it. For these reasons the Western and Southwestern oils will probably never compete with those from the Eastern

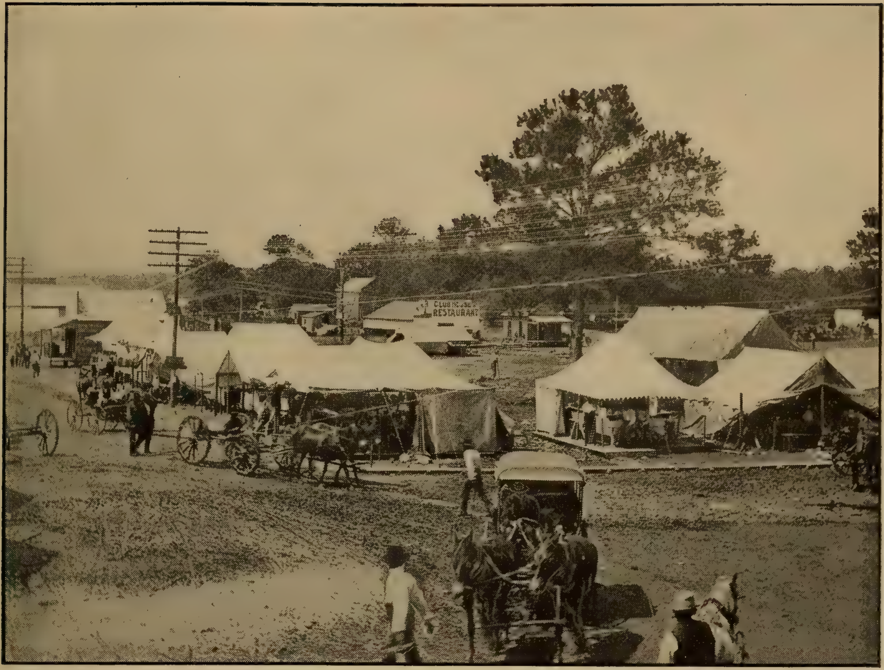
OIL WELLS IN THE CALIFORNIA DESERT

fields, being used principally for fuel in their crude state and for the manufacture of lubricating oil.

The enormous waste of this resource can never be estimated, for the well-boring until recent years has been attended with no method of securing the flow of oil. In Texas it was allowed to flow through open ditches into basins dug out of the earth, as the wells came in so rapidly that there was no time to build reservoirs or pipe lines. Many "gushers" were allowed to throw their contents into the air, to advertise the site of the "boom" town and sell lots. The few tanks built at Spindle Top and Sour Lake were allowed to overflow, no steps being taken to preserve the oil.

But in the present petroleum production the wasteful methods have been abandoned and care taken to preserve the flow of each well. When a boring is made in an oil-bearing territory a heavy iron cap is provided that can be bolted at once on the top of the piping to prevent the petroleum from flowing out until the well can be connected with a reservoir. Laws have been enacted to prevent "gushing," and requiring flowing wells to be capped unless connected with a storage depot by conduit. In the Eastern and Western oil fields thousands of abandoned wells have been examined and deposits of oil found that can be drawn to the surface. Consequently, a large quantity of the liquid in fields supposed to be exhausted is being secured by pumping systems operated by steam or electricity, where electric transmission is available.

It may be said that the Standard Oil Company is largely responsible for the present efficient and economical system for conserving our petroleum resources. With its broad facilities, it has been able to construct pipe lines, storage reservoirs, and to convert the petroleum into literally hundreds of different commodities, such as illuminating oils, gasoline for motor power, lubricants, also soaps and medicines. Connect-



STARTING A NEW TOWN IN AN OIL DISTRICT

ing its sources of supply with its refineries and reservoirs are "trunk" conduits extending from the Mississippi river to the Eastern seaboard. To these trunk lines come feeders from the well districts.

Altogether, the Standard Oil Company operates nineteen large refineries. The largest of the nineteen is the one at Bayonne, N. J. It covers an area of 400 acres and employs 6,000 men. Within its buildings are carried on a great many auxiliary industries, aside from the mere distillation of the oil. In one part of the workings is a remarkable apparatus that performs several different operations—making the oil cans, filling them with oil and placing them in packing cases by means of conveyors at the rate of 60,000 cans a day. From it emerge the completed packages, carried on an endless belt to the shipping room. Within the machine the tin plate of the top, bottom and sides of each can are stamped out and crimped together. The can is mechanically filled with oil and soldered. It is boxed in a wooden case, nailed together by the machine, and is ready for export.

The crude oil is pumped from the refinery storage tanks into stills that stand in isolated rows. The stills are boilers, beneath which fires are kept burning for three days after they are filled with oil. As the temperature rises, the mixture begins to seethe and boil and to swell up with rapidly generating gases. These are drawn off through long coils of pipe and condensed to a liquid form again under cold water. First of all come the lighter oils—the ethers and naphthas—which vaporize very readily. Next come the illuminating oils, which are heavier and require greater heat to vaporize. Further distillation extracts many grades of illuminating oil, gasoline, wax, and roofing pitch. The residue in the bottom of the still is a solid product known as coke, that is used for carbon points in electric lights and for fuel in some of the boilers. The products of the first distillation are in a more or less impure state, and require further treatment before they are ready for the consumer. They are cleansed with sulphuric acid in cylindrical agitators and then redistilled to make them colorless and to bring them up to the standard required by the government. This corporation has such an export business that American oil goes into nearly every country in the world.

How well it has succeeded is indicated by the brief statement that 60 per cent. of the refined oil it produces in the United States is shipped abroad, and that in thirty years its foreign sales have aggregated almost $1,750,000,000.

Its storage facilities are so complete and capacious that a continual supply can be furnished the refineries and other plants. In the fields where the Standard provides the only means of marketing oil the producer demands that his entire production be drawn off as fast as his well yields it. This is desirable from the producer's standpoint, as it enables him to take out his share of the oil from the common reservoir from which all the well operators are drawing. When the oil flows rapidly it is necessary to store it away in great iron tanks, from which it can be withdrawn as occasion demands. These tanks are 90 to 115 feet in diameter and 30 to 40 feet high, and are assembled in groups of 50 or 60 in "tank farms" that are frequently a mile long and a half-mile wide. Each tank holds 35,000 barrels of oil, bringing the total store well up into the millions. In the Kansas field alone the stock of crude oil in storage at times amounts to more than 40,000,000 barrels, worth $15,000,000.

# THE RAILWAYS OF BRAZIL

By Lionel Wiener

## XIV.—THE RAILWAYS OF THE RIO GRANDE DO SUL

THE Rio Grande do Sul railway system is the only one that is directly influenced by that of the neighbouring Republics. It is also the only one whose main lines, forming the skeleton of the future system, have reached completion. It has, therefore, an interest peculiarly its own.

These lines have only just reached completion; in fact, their last sections have been opened to traffic only since the end of 1910. And already it has been decided to complete their network, and the Government has invited tenders for what we might call "the second system."

All the Rio Grande lines belong to the Union, and this has been a thorn in the side of the State, notwithstanding the fact that such lines as the State did build or work proved an encumbrance to it, and have been voluntarily handed over to the Government of the Union.

The aloofness of the Rio Grande is easy to account for, geographically. It almost looks as if it had been accidentally joined on to the southern portion of Brazil. It is complete in itself, with natural frontiers, and is as individualistic and separate as is the Republic of Uruguay, beyond. Both have the sea as eastern boundary, and the Rio Uruguay, on the west, separates both from the Argentine Republic. But though the area of the Rio Grande is larger than that of Uruguay, its population is smaller.

There is another special feature here—an eastward-running stream, the Jacuhy, and its tributary, the Vacacahy. From the centre of the State, near Santa Maria, these streams flow eastward, while the Ibicuhy, whose source is nearby, flows westward. The upper Jacuhy (above the confluence of Vacacahy) flows north and south, at right angles to its lower course, as do all the larger tributaries. This is due to the coastal range of hills taking a bend inland on entering the Rio Grande do Sul, which it crosses approximately in an east and west direction, with lesser ranges running longitudinally between the Jacuhy's tributaries. This divides the State into a northern plateau, difficult to scale, and a southern portion, the boundary line, running latitudinally, a little north of Uruguayana, through Santa Maria, and just north of Porto Alegre, the capital.

The Jacuhy does not flow directly into the sea, but into a long laguna, called the Lagoa dos Patos (lake of drakes), with the Lagoa Mirim (small lake) beyond, in the south. These long lakes, parallel and close to the coast, are connected by the Rio Sao Gonçalo, and have an outlet seaward between them at Rio Grande. No railway has been built between Porto Alegre and Rio Grande, the two most important towns and harbours of the State, as sea-going vessels can ply along the laguna. But both towns (between which there is no little jealousy) are joined to the centre of the State, whence the common trunk line continues beyond to Uruguayana. The line follows the foot of the northern plateau, along the Jacuhy and Ibicuhy valleys, running from Porto Alegre, through Santa Maria, Cacequy, and on to Uruguayana, on the west frontier. This is the main line of the obsolete Porto Alegre & Uruguayana Rail-

ALEGRETE, A TYPICAL STATION ON THE RIO GRANDE RAILWAY

way (P. A. U. Ry.). The Rio Grande line runs through the important towns of Pelotas and Bagé, and joins the P. A. U. main line at Cacequy. The Rio Grande and Bagé portion was built by a separate company.

But it was necessary, besides, to join the State with Rio de Janeiro, in the north, and southward with Montevideo, and this has been done from the centre.

The southern line starts from a point a few miles out of Cacequy and runs due south to Santa Anna de Livramento, the frontier station whence the northern extension of the Central of Uruguay Railway continues through to Montevideo.

On the other hand, an old Belgian

LOCOMOTIVE SHEDS, SANTA MARIA STATION

company's line, the "South West Brazilian," runs north from Santa Maria through Cruz Alta to Passo Fundo. An extension to the upper Uruguay river, which is the frontier stream between Rio Grande and Santa Catharina, has been built by the present lessees. This line crosses the upper Uruguay opposite its confluence with the Rio de Peixe, a Santa Catharina stream, where it joins the Sao Paulo & Rio Grande Railway.

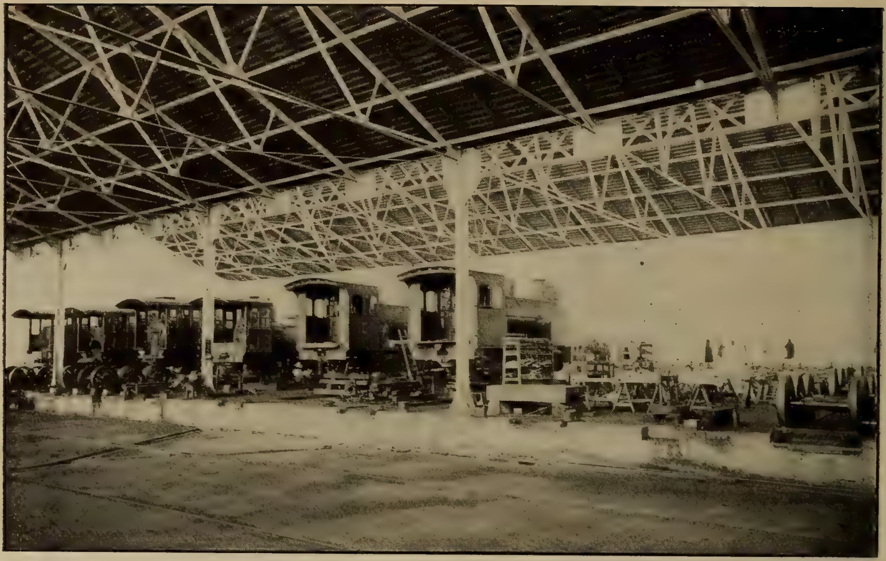
Besides these "inner lines," there are frontier ones, both along the eastern and western frontiers.

The western line, which belongs to the "Brazil Great Southern Railway," follows the Uruguay river from Quarahim, in the south, through Uruguayana to Itaquy. It is more a strategical line than anything else, and will run northward along the stream as far as does the Argentinian line, on the opposite bank. It seems a waste, in a country where railways are still so scarce, that there should be a railway line upon either bank of a navigable river. The Argentine line, which belongs to the "Argentine North Eastern Railway," runs from Monte Caseros, opposite Quarahim, to Libres, opposite Uruguayana; Alvear, opposite Itaquy, and San Tomé, opposite Sao Borja. The "Brazil Great Southern Railway" is, therefore, building an extension to this latter place. Beyond San Tomé the Argentine line runs due north, and is, therefore, less of a menace to Brazil.

Along the east coast the lines are not continuous, as they are in the west. There is a line north of Porto Alegre to Caxias, the present terminal, with an eastern branch from Neustadt to Taquara, close to the coast. The main P. A. U. Railway line also branches off this Caxias line in Montenegro.

South of Porto Alegre the lake extends to Rio Grande, whose harbour, though in deep water, has little traffic, owing to a bar across its mouth. A French company has been floated to cut a canal through the bar and throw the harbour open to vessels of deep draft. Should the

CONSTRUCTION WORK ON THE RIO GRANDE RAILWAY



REPAIR SHOPS OF THE RIO GRANDE RAILWAY

works in progress succeed—and there seems to be every likelihood that they will — Rio Grande harbour is likely to become in a very few years one of the best and deepest in South America, and thereby to benefit the State and its railways to a very considerable extent. The amount of water that runs through the estuary at Rio Grande is enormous, equaled by only three or four other streams in the whole world.

South of Rio Grande the Laguna Mirim is navigable to Port Victoria, in the Republic of Uruguay. A short line will connect Jaguarao, a frontier town, with some station of the Rio Grande & Bagé line, which keeps near the frontier as far as Bagé. There is no frontier line from this town to Santa Anna do Livramento, where the main longitudinal line crosses the frontier, but work upon such a line will be started shortly. It will run through Dom Perdito, whose jerked-beef factories, with those of Santa Anna, are the largest of the State. The object of this line would be to divert their exports to the harbour of Rio Grande instead of following their present route to Montevideo. The possibility of doing this depends, not on the railway freight only, but also, to a great extent, on the Rio Grande harbour dues and the ocean freight charges beyond.

Such is the rough outline of the railway system, which we will now proceed to examine. But a number of navigable streams, upon which river services are maintained, should be added, not so much because of these services in themselves as because of the importance the State attaches to them, doing what it can to prevent railway lines competing with them.

In the west, during the wet season, steamers run up the Rio Uruguay to San Borja, and up its affluent, the Rio Ibicuhy, to a point near Cacequy.

In the east, four of the Rio Jacuhy's affluents join it near Porto Alegre, and these five streams are navigable some distance inland: the Rio Jacuhy, up to Cachoeira, and occasionally up to Santo Angelo; the Rio Cahy, up to Sao Sebastiao; the Rio Taquary, up to Lageado; the Rio dos Sinos, up to Taqrara, and the Rio Gravatahy, up to the town of Gravatahy.

The "Compagnie Auxiliaire des

92474

RAILWAY BRIDGE ON THE URUGUAYANA LINE

Chemins de Fer au Brésil" is a Belgian company, which has leased almost the entire system for sixty years.

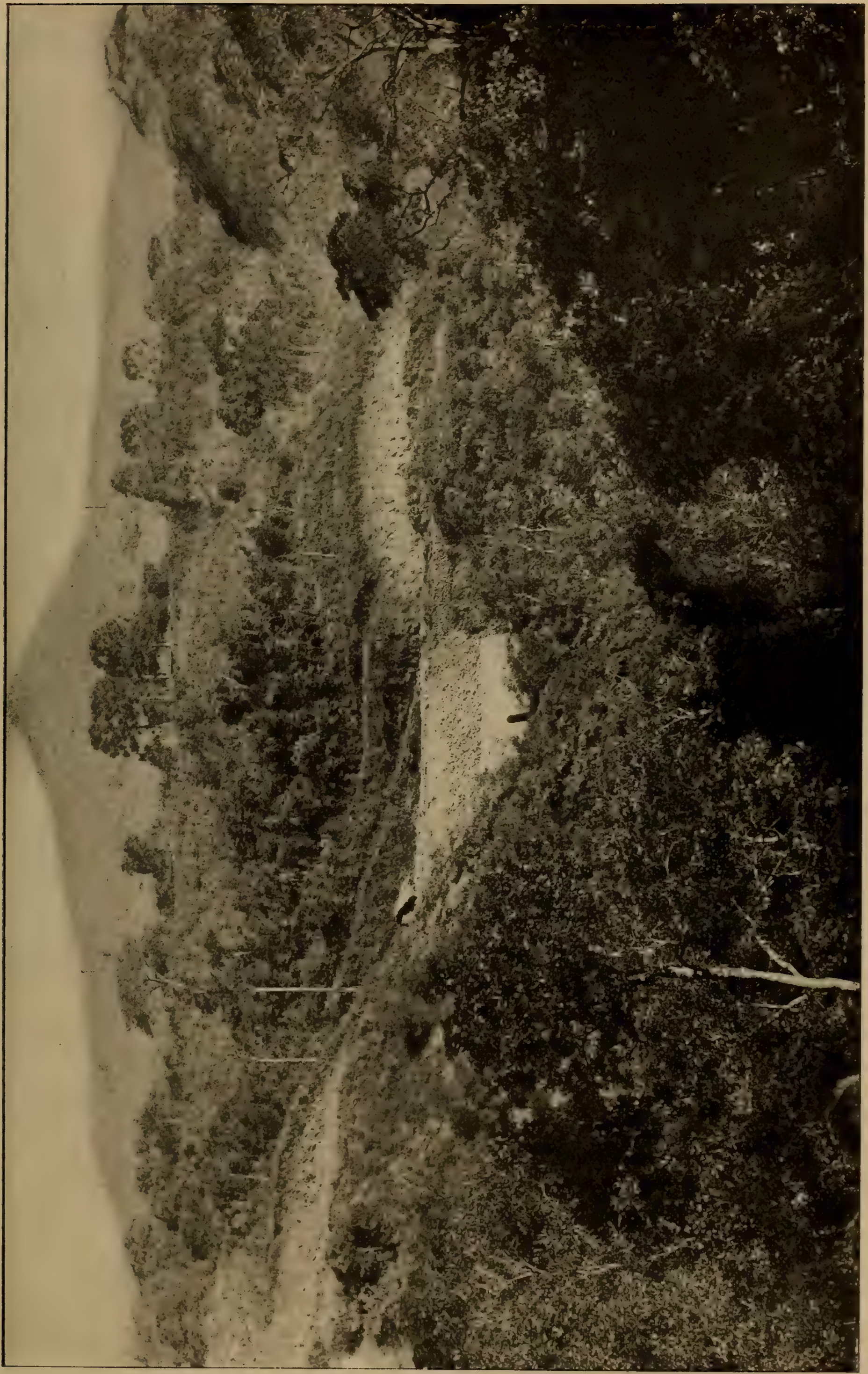
The earliest of these lines, and the oldest one in the State, runs from Porto Alegre to Novo Hamburgo, a distance of 26 miles. It was built by an English company and opened to traffic in 1876. I suppose it was at first more of a tramway than a railway, and the promoters could certainly not foresee that this short road would eventually become the original section of the main line connecting Porto Alegre with the rest of Brazil. The Porto Alegre terminal is situated on the banks of the Rio, and from here the line is laid in the street, parallel to that of the electric tramway. It is rather odd to note that the latter looks far the more important of the two, because the railway is laid to the metre gauge, as are all those of the State, and with a light 36-pound rail, whereas the tramway is broad gauge, and its rail weighs 100 pounds to the running yard. It was usual to build these early metre-gauge lines cheaply, and this has led to a curious development: the lack of the intermediate-size terminal. The original one is used as long as possible, and, when it will do no more, the work of removing the line from the street entails such an outlay that the terminal is rebuilt on a corresponding scale. Such is the case in Porto Alegre, where a new terminal will have to be built on land reclaimed from the river and the new egress laid along the river bank. This railway seemed called upon to serve an important suburban traffic, but has hardly realized expectations, as far as this was concerned, having been worked at a loss most of the time.

In 1903 a Brazilian company, Messrs. Correa & Co., obtained a "stadoal" concession of a line from Novo Hamburgo to Neustadt and Taquara, competing with the Rio dos Sinos Navigation Company. It crosses this river on a fine bridge between the two first-named towns. Its length is 511 feet.

The road was worked at a loss during the first three years and at a profit since. The State, which had bought back the older portion from Porto Alegre to Novo Hamburgo in 1903, purchased this extension in 1905. This has had a great influence—too great a one, in fact—on the building of the other lines, the State wishing that all traffic should pass over its own metals and so obliging the new line to go out of their way to do so. But, the operation not turning out as satisfactorily as had been anticipated, the State agreed (in 1905) to sell the lines to the Federal Government, who leased them, with the others, to the "Compagnie Auxiliaire."

Nor was this the only British company in the Rio Grande do Sul. The Rio Grande & Bagé Railway, 177 miles long, though originally Brazilian and then French, was handed over to an English company on the day of its inauguration, in 1884. The original lessees, Messrs. da Cunha, Plant & Co., had been granted a "tramway or light railway" in 1867 from Rio Grande to Candiota, near Bagé, the centre, as the contract stated, of the southern coal field. It is as well to note that no further steps have ever been taken in connection with these mines, though the existence of coal has been proved. A 19-mile privilege zone was granted at the same time, and the usual clause inserted stipulating that any Brazilian employed on the railway should be exonerated from military duty.

In 1870 the Province of Rio Grande subscribed a capital expenditure of £120,000, and in 1874 another Imperial decree authorized the railway survey from Rio Grande to Bagé, with an extension from Bagé to Dom Pedrito, Rosario and Alegrete—rather a strange way of getting there. This survey was to be made both for 5-foot 3-inch and for metre gauge, with the usual



VIEW ON THE CAXIAS BRANCH, RIO GRANDE RAILWAY

MONTENEGRO STATION, CAXIAS RAILWAY

grade and curve restrictions for each; but no decision had been come to as to the building or future ownership. It was only in 1878, when a decree granted 7 per cent. interest on capital expenditure for the metre gauge line, that Messrs. da Cunha and James Taylor became the definite lessees, and that they transferred their rights to the "Imperial Company of Rio Grande Railways," the French construction company, who handed the line over to the British "Southern Brazilian Rio Grande Railway" upon completion.

Leaving Rio Grande, on the seashore, where the harbour works that were first begun by the "Brazilian Public Works Company," a French concern, were given up, and started again in 1908 only, the railway first runs northward, crossing the Sao Gonçalo river into Pelotas. This river is navigable, the Porto Alegre steamers following it from the Lago dos Patos to the Lago Mirim and up the Rio Jaguarao to the town of Jaguarao, a short distance up-stream. The bridge over the Sao Gonçalo has four fixed lattice girders of 185 feet each and a 153-foot swing span, which brings the total up to 708 feet.

It is from Pelotas that the "Pelotas Colonies Railway" was intended to start. This was a British concern, floated in 1889, for building a line northward to San Lourenço. But, though there was a 6 per cent. guarantee of interest and work was actually started, the company was unable to do more than build the substructure for some half-a-dozen miles.

The Rio Grande & Bagé Railway next passes through Cerro Chato, Santa Rosa, and so on to Bagé, which it reaches at the 177th mile, after having climbed the Serra, which separates the Atlantic and Rio de la Plata watersheds. This hard piece of line is one of the sections on which the Mallet locomotives are used.

The works of the old company are extensive, and were situated in Rio Grande, where they have remained.

The only extension to the original line took place in 1900, when the "Southern Brazilian Rio Grande Railway" purchased the "Costa do Mar" steam tram line of the Rio Grande Tramways Company for the sum of 100 contos (some £4,000 sterling). This line is but ten miles long, and leads to Villa Siqueira, a fashionable seaside resort.

The company worked its main line successfully until 1905, when it was handed over to the Compagnie Auxiliaire and merged into their system.

The third road incorporated with it has a curious history, because it belonged to it originally, was then transferred, owned again, sold a second time, and finally returned to the original promoters. This is how it came about. In 1889 Mr. Soares, the Brazilian Railway King, was granted a line from Itararé, on the frontier of the State of Sao Paulo, into the Rio Grande, through Ponto Grossa, Passo Fundo and Cruz Alta to Santa Maria, besides two branches, one in the State of Parana and the other from Cruz Alta to Ijuhy and the mouth of the Rio Camandahy, 183 miles in length. This is the railway that eventually became the "Sao Paulo & Rio Grande Railway" in the States of Parana and Santa Catharina, which we have already examined. But it is inseparable from the Rio Grande portion, as their early history is tied up together.

In 1890 the "Chemins de Fer Secondaires," a powerful Belgian railways and tramways syndicate, formed a special company: the "Chemin de Fer Sud Ouest Brésilien," to whom Mr. Soares handed over his lease, together with the 6 per cent., thirty years' guarantee (the milreis at *27d.*) and a fine belt of forest land on either side.

VIEW ON THE CAXIAS RAILWAY, THE OLD AND THE NEW

The portion north of Cruz Alta, including both branches, was handed over to the "Industrial Union of the United States of Brazil" in 1893, who, in turn, transferred it to the Sao Paulo & Rio Grande Railway.

The southern portion, which it had kept—some 100 miles long, between Santa Maria and Cruz Alta—was opened to traffic in 1894. The orig-

TEMPORARY VIADUCT ON THE URUGUAYANA RAILWAY

inal section is remarkable, because the "Serra" has to be scaled on leaving Santa Maria. This has been accomplished by an almost continuous grade of 30 millimeters (1 in 33.3), combined with curves of 330-foot radius (and occasionally less) and reverse curves. The line is most picturesque, but less than one-third of it consists of tangents. Thus the first nine miles account for an 1140-foot difference of altitude.

In 1895 the "Sao Paulo & Rio Grande Railway" handed back all the portion of its system which was in the State of Rio Grande—that is to say, the Cruz Alta Uruguay river section of its main line and the Cruz Alta Ijuhy branch. These lines, like the rest, might be bought back by the Federal Government after the first thirty years, and the rates—which, by the way, are higher than those of the other lines of the State—were to be cut down should the net receipts reach 12 per cent. of the recognized capital.

The company set to work and opened the first half of the main-line extension, some 121 miles, to Passo Fundo, in 1898. This is all it built, and the Government bought it up in 1901 and worked it under the name of Santa Maria & Uruguay Railway until 1905, when it leased it, with the other lines, to the "Compagnie Auxiliairo," withholding the Ijuhy branch. Upon this, it set the second battalion of engineers to work in 1907, who built some ten miles a year. The first section, which was opened to traffic in 1910, was handed over to the Compagnie Auxiliaire, who work it, the "Chemins de Fer Secondaires," who also formed this company, thus becoming the possessors of this Ijuhy line for the third time.

I have left the Porto Alegre & Uruguayana (P. A. U.) line to the last, because its lessees have gradually absorbed all the rest.

This line was built by the Government from Margem, a river harbour four hours from Porto Alegre, along the left bank of the Jacuhy to Cachoeira in 1883, and on to Santa Maria, at the 163d mile, in

1885. A special service of steamers plies in connection with the railway between Porto Alegre and Margem, which is just a little way up the Rio Taquary, the largest tributary of the Jacuhy. The Government built extensive workshops there and an interesting station. The Taquary often has floods, and though it is here the best part of a mlie in breadth and never less than 52 feet deep, it has risen as much as 36 feet above that, and, during normal rainy seasons, to a depth of 72 feet. The station is, therefore, a large wooden structure, supported by stone piers above highest water mark. There is also a low-level goods station and yard, both stations being provided with the necessary cranes, etc.

Keeping, as it does, so near the river bank, there are, of course, a number of large bridges, the principal being the one over the Rio Pardo, in six spans, and 528 feet long the single-span, 248-foot bridge over the Rio Botucharahy, and the bridge over the Jacuhy. This bridge, which is 1,386 feet long, has thirteen spans, the longest of which is 198 feet in length.

Whilst this line was under construction the Rio Grande & Bagé line was opened. The Government, therefore, prepared plans for extending its own line so as to open up connection with the Bagé line. The original extension of that road had not been built, and it was decided to build a line from Bagé through Sao Gabriel and Cacequy to Santa Maria, which has been eventually accomplished. This was a mistake, considering that the northern line passes at Santa Maria, which is the real railway centre of the State. The Bagé line should have been run direct from Sao Gabriel to Santa Maria, and an extra line from Bagé to Porto Alegre is certain to be built some day, as the Cacequy route is far too roundabout.

The first seventy miles from Santa Maria to Cacequy, which are laid down the Ibicuhy valley, were opened in 1889 and 1890. The Cacequy-Bagé section was started at both ends, the 48 miles from Cacequy to

CONSTRUCTION WORK ON THE CAXIAS BRANCH OF THE RIO GRANDE RAILWAY

Sao Gabriel having been opened in 1896, the same year as the 17 miles from Bagé to Sao Sebastiao. But the intermediate 58 miles, which included the scaling of a ridge some 600 feet high, was left out and built by the "Compagnie Auxiliaire," after leasing the road, in 1898, and was opened to traffic in 1900.

The lease included the entire P. A. U. Railway, while the Government continued to build the extension from Cacequy to Uruguayana, 163 miles long. This extension had been begun by the Government, and a portion, from Uruguayana to Alegrete, was opened to traffic in 1907. This being separated from the rest of the system, was temporarily worked by the Brazil Great Southern, whose line passes in Uruguayana, in the same manner as the Bagé-Sao Sebastiao section was worked by the company, whose terminal was in Bagé, until it was united with the rest of the system. The battalion of engineers even started work on the Cacequy-Alegrete stretch, but made little headway.

The general contract of 1905 obliged the company to build this missing link, which it opened to traffic on November 22, 1907.

This 1905 contract is of importance, as it created the system as it is, grouping in the hands of a single company six distinct railways, one of the clauses stipulating the building of a number of extra lines. The "Brazilian Great Southern Railway" was alone left out: we will give a short description of this line further.

The Compagnie Auxiliaire has leased the following lines:

| | Miles. |
|---|---|
| Margem to Santa Maria, and from there to Uruguayana | 398 |
| The Parodao branch (goods only) | 2 |
| Cacequy to Bagé, and on to Rio Grande | 371 |
| The Villa Siqueira branch | 10 |
| Porto Alegro, to Novo Hamburgo and Taquara | 55 |
| Santa Maria, Cruz Alta and Passo Fundo | 222 |
| | 1,058 |

The Porto Alegre, Novo Hamburgo and Caquara Railways, and the Santa Cruz and Caxias branches, building, all of which belonged to the State of Rio Grande, were sold to the Federal Government and merged with the remainder of the system.

The system is divided into three groups as far as rentage is concerned, the company paying 30 per cent. on the gross earnings above a certain sum, different for each group. For two of them the company also pays 5 and 10 per cent., respectively, of the earnings up to a sum limit. Should the total earnings reach 12 per cent. of capital expenditure, 20 per cent. of the surplus shall be paid to the Government.

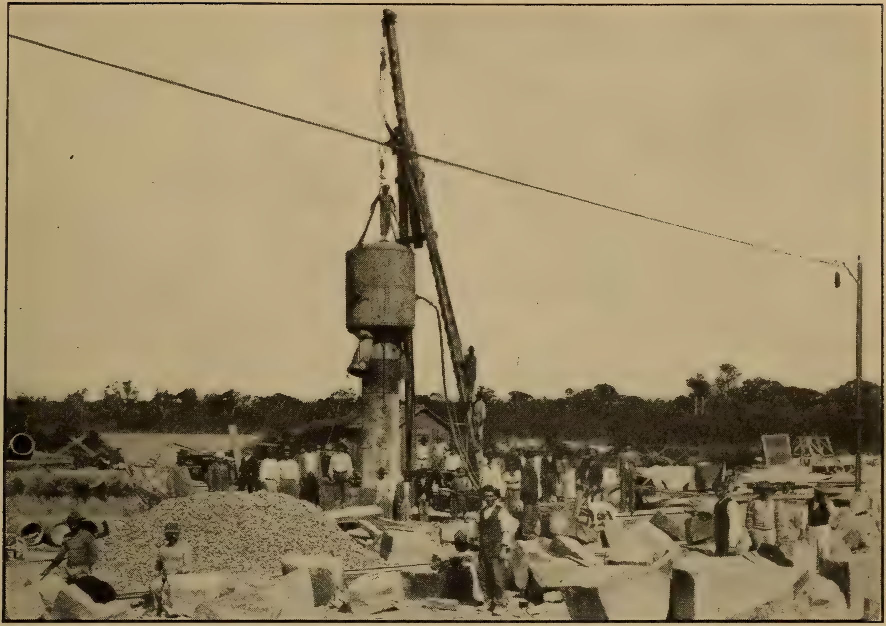
Should the Government wish to buy back the lines, it must pay 25 per cent. of the net annual earnings (average of the last five years) multiplied by the number of years the lease still runs, besides returning a sum equal to the capital expenditure, from which a certain amount has been deducted. This amount is calculated as follows:

$$A = \frac{a\,(1.06^{n})-1}{0.06};$$

$a$ being the annuity taken at 6 per cent. and $n$ the remaining number of years.

This company was also to build a certain number of specified lines within definite periods. An extra clause states that, should unforeseen difficulties arise (and these include difficulty in securing labour), the time shall be lengthened, thus rendering the contract somewhat elastic. It should also be borne in mind that all construction work is priced beforehand, and that there is usually some margin in the company's favour, the latter acting as a construction contractor.

The "Compagnie Auxiliaire" immediately undertook the building of these new lines, which it brought to a satisfactory conclusion in 1910, and which we will now proceed to examine. These include the completion of the Porto Alegre & Uruguayana line, of the Cacequy-Bagé branch, which we have previously examined, and three new lines: to Caxias, to the upper Uruguaya



FOUNDATION WORK ON THE PONTE SANTA MARIA

river, and to Santa Anna de Livramento.

a) Porto Alegre Uruguayana main line.

This latitudinal line had two gaps, both due to the magnitude of the bridgework which they required. One was between Alegrete and Cacequy, built before the end of 1907; the other, between Margem and Porto Alegre, finished at the end of 1910.

Lack of space forbids a detailed description of all the bridgework, much of which is remarkable. We will, therefore, only mention the more important bridges—say more than 150 feet in length.

Between Cacequy and Saycan, the first station, the Rio Santa Maria (a large affluent of the Ibicuhy) must be crossed, the contract authorizing the company to build a bridge or a tunnel. A temporary wooden, low-level bridge was erected and used successfully from 1907 to 1911. It had been the intention of the Government to build a number of bridges connected by short embankments. But the company feared the floods (and the flood of 1903 showed that it was with good cause), and decided to build one long bridge, turning the old abutments into piers. This accounts for the odd spans of the bridge.

The portion over the river bed is a cantilever bridge 1,122 feet long. The entire bridge is 5,118 feet long, and comprises twenty spans. It is the longest bridge in Brazil, the Laguna bridge being but 4,620 feet in length and the Ibicuhy bridge, on the Brazil Great Southern Railway, a little under 4,000 feet. But this short 6-mile section has also a 155-foot, single-span bridge, a 495-foot bridge over the Rio Saycan (in three spans), and seven smaller bridges.

The Itapévy bridge, a little farther, has a single span of 396 feet, the longest in Brazil. The Ibirocahy bridge is a fine skew bridge, 363 feet long, and the fifteen other large bridges range from 165 feet up to 546 feet in length.

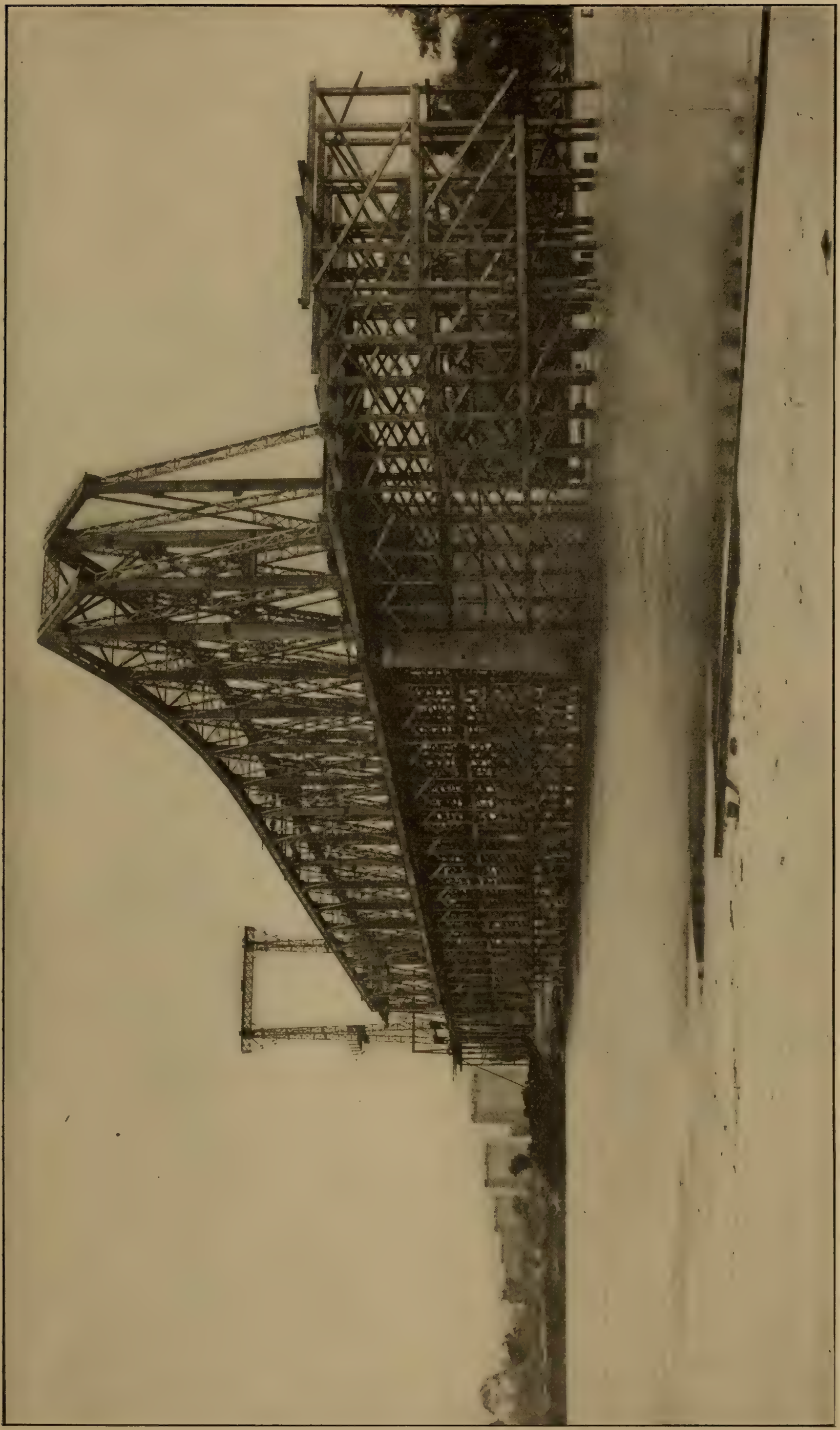
The bridges built by the Government and by the older companies are lattice-girder bridges built for a load of 8 tons per axle. Those built by the Compagnie Auxiliaire are semi-parabolic, discontinuous Warren trusses, built for 10 tons per axle, and are rather light. Thus, the girder of the Itapévy bridge weighs but 465 tons, and the entire metallic structure of the Santa Maria bridge weighs 3,200 tons.

The whole of the Uruguayana extension is badly located; it is too far south, and should have kept to the right bank of the Ibicuhy instead of the left. Neither Cacequy nor Alegrete is a town of importance, while the other route would have run through Sao Vicente and Sao Francisco and taken the line to Itaquy instead of Uruguayana, which is of no moment. The line is a frontier one now and would be cut off easily, whereas it would have been an easy one to defend had it been built on the river's right bank.

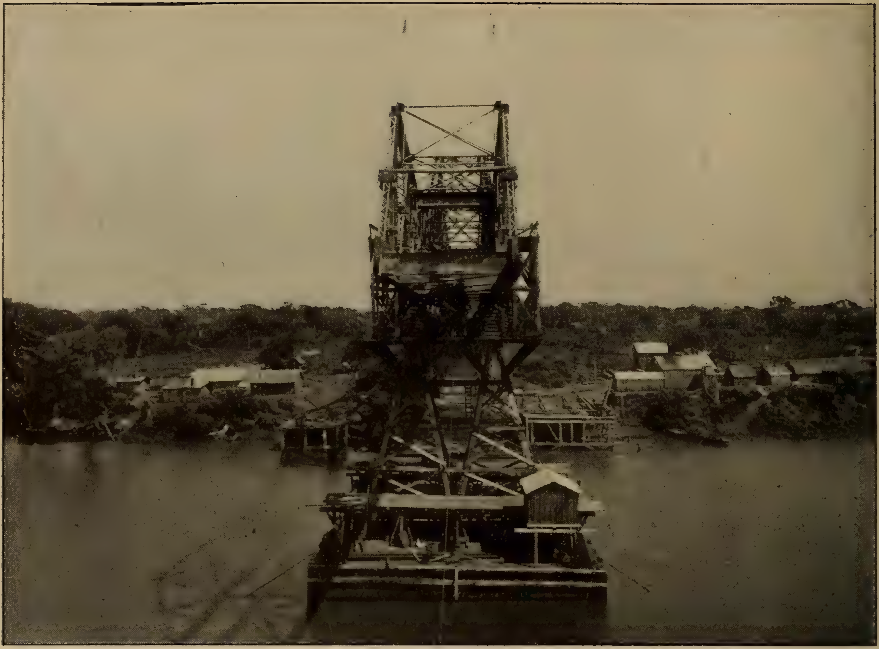
Margem, the terminal, was to be joined to Porto Alegre. An old survey had been made along the river bank straight there, but instead the company has been obliged to build the line through Montenegro, where the Caxias line joins it, and Neustadt, the junction with the old Taquara line. This is a most roundabout way, the object being to prevent interference with the river navigation. But river competition being keen, both from Montenegro and from Margem, all rates have been cut down between Porto Alegre and Cachoeira, reached by the steamers, as if the line were really 30 per cent. shorter than it is.

The new line leaves the old one a little before reaching Margem, so as to cross the Rio Taquary a little way up-stream on a fine cantilever bridge, identical with the cantilever portion of the Rio Santa Maria bridge. But the Taquary bridge, which is 1,115 feet long, and whose superstructure weighs but 1,100 tons, is remarkable because of the depth of water in which it has been built. The piers are 128 feet high from the foundations, and the depth of water always considerable. This has entailed erecting the trusses on the banks—a difficult piece of work on the Margem bank, where it had to be done on the top of an embankment 60-odd feet high. Another 1,584 feet of bridging has been erected beyond (in six spans), to

APPROACH OF THE PONTE SANTA MARIA, RIO GRANDE RAILWAY



ERECTION WORK ON THE GREAT CANTILEVERS OF THE PONTE SANTA MARIA



CONSTRUCTION OF THE PONTE TAQUARY

avoid damming up the river during the floods.

Immediately beyond Montenegro the line crosses the Cahy on a bridge comprising one 264-foot and two 132-foot spans. There are five other bridges, of 176 feet each, across the thalweg of this valley, bringing the total up to 1,408 feet of bridging on a length of 6,600 feet of line.

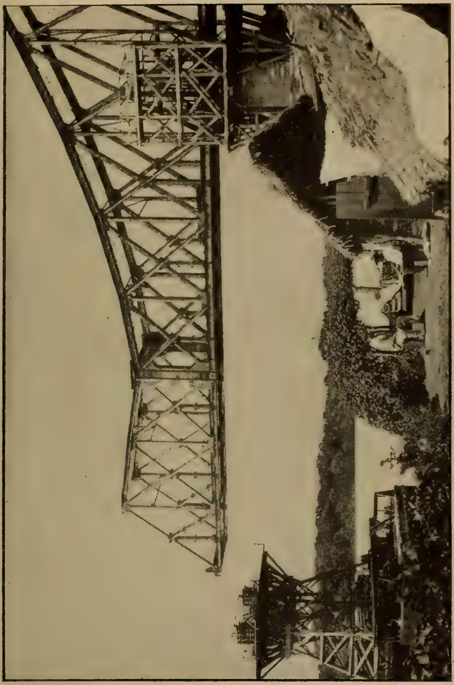
b) The Caxias line.

This line was projected, and, in fact, begun, by the State through a land rich in Italian colonies and their products, so as to bring down traffic that would run over its metals from Montenegro to Porto Alegre. It is an interesting line, scaling the Serra do Mar in the most beautiful portion of the State. There is an almost continuous grade of 1 in 45, though the line has been artificially increased to double its length. The distance from Marata to Barao by rail is 25 miles, and the difference in altitude 2,055 feet. There are many high retaining walls, and the only tunnel in the State.

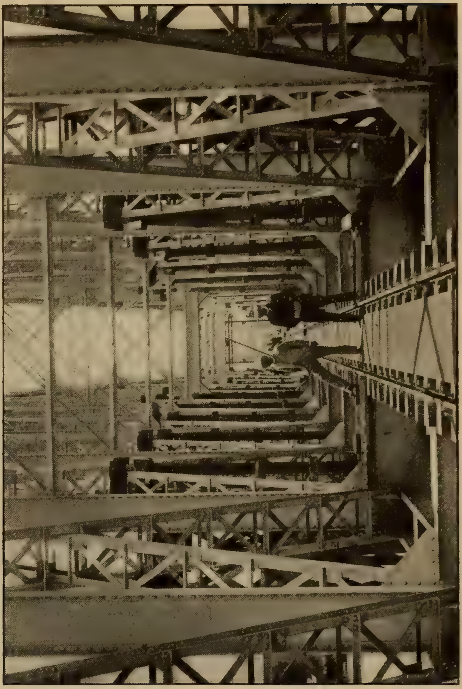
c) The Passo Fundo & Rio Uruguay line.

This extension of the Chemin de Fer Sud Ouest Brésilien is most important, as it opens up connection with the roads leading to Rio. It lies entirely through virgin forests, and was exceedingly difficult to locate, particularly along the long descent to the Rio Uruguay at the frontier. Owing to its political importance, it has been pushed ahead at an exceptional rate, and temporary timber viaducts erected, so as to get past the difficult bits. These viaducts, of which there are five in succession, are both on grades and curves, the grade being 1 in 33 for one and 1 in 66 for the others, in combination with curves of only 165-foot radius. A single guard rail is, therefore, insufficient, so several have been laid. Three of these viaducts are as much as 60 feet high. They took but two months to erect in a most difficult country.

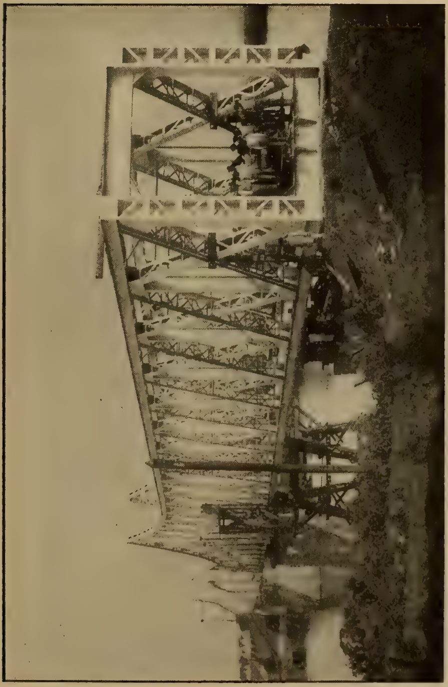
The definite metallic viaducts are Murphy-Whipple discontinuous



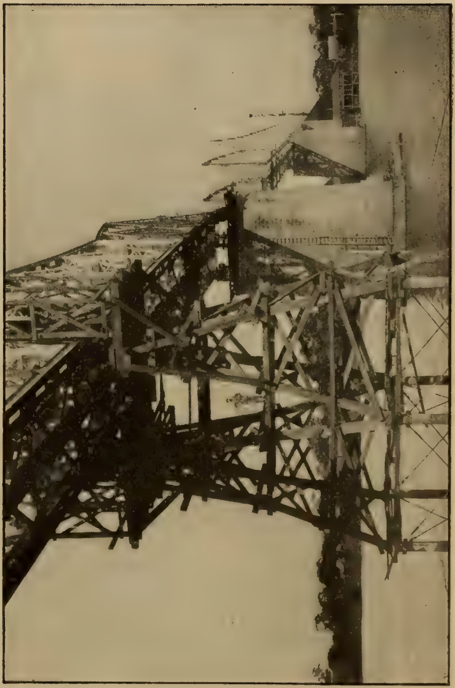
A CANTILEVER OF THE TAQUARY BRIDGE



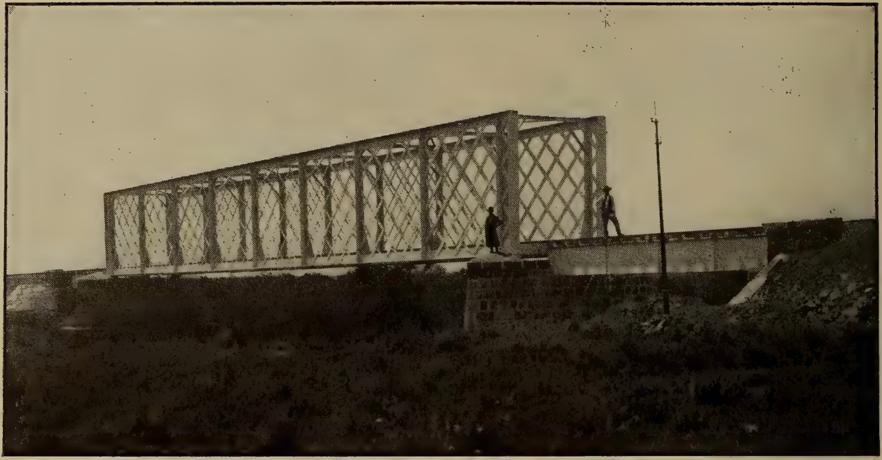
LOOKING THROUGH THE PONTE TAQUARY



LAST STAGE OF LAUNCHING OF THE PONTE TAQUARY



TEMPORARY WORKS UNDER THE PONTE TAQUARY



LATTICE BRIDGE ON THE URUGUAYANA LINE

trusses, resting on metallic piers. All are on a 1 in 55 grade, and all but one, which is straight, are on 396-foot radius curves. Their lengths are 429, 346, 330, 330 and 610 feet. All spans, except the abutment spans and the centre 132-foot span of the last viaduct, are 82.5 feet long.

The bridge over the Rio Uruguay should also be mentioned. The stream is usually low, and can often be crossed on foot. But there are frequent and sudden swellings, and the current is at all times very swift. A temporary timber bridge has been erected, the definite one, which will be finished shortly, being 1,401 feet long, six of the spans being 205 feet. These six spans consist of two through lattice continuous girders of 615 feet.

4) The Santa Anna de Livramento line.

Though branching off the P. A. U.

BRIDGE OVER THE RIO DOS SINOS, CAXIAS RAILWAY

VIEW THROUGH THE PONTE TAQUARY

line immediately beyond Cacequy and striking due south from that point, it is really the southern extension of the Passe Fundo line, the trains following the P. A. U. line between Santa Maria and Cacequy on their way from the north to Montevideo. Apart from a few large bridges, it contains no engineering structures of importance.

It should not be understood that, because of the heaviness of the bridging, the Rio Grande is a low-lying, wet country. It is undulating everywhere, often hilly, and not unfrequently mountainous, but exceptionally overrun with impetuous rivers, that are apt to deliver abnormal masses of water, though many of them are sluggish or even dry during part of the year.

This branch opens up connection with Montevideo. Santa Anna is a Brazilian frontier town, and on the other side of the frontier is the town of Rivera, from which it is separated by the width of a street. This is not a solitary instance of such a situation. Quarahy, on the Brazilian side, is separated from Sao Eugenio (Uruguay) only by the Rio Quarahy, a small stream; Jaguarao (Brazil) is separated from Artigas (in Uruguay) in the same way by the Rio Jaguarao, and almost all the towns of any importance on the Rio Uruguay can hobnob with towns on the Argentinian bank of that river.

Instead of having contractors to build the Passo Fundo & Rio Uruguay line, the company built it as an experiment, which, apart from the difficulty of securing a sufficient number of workmen, has been successful. This line was added to the 1905 contract in 1906, the company bearing half the cost up to a maximum of £396,620. The difference is paid by the Government in Brazilian 6 per cent. shares.

The company has thus added to the system it leased in 1905:

| | |
|---|---|
| Portion of the Cacequy Bagé line.. | Already counted |
| Alegrete to Cacequy.............. | Already counted |
| | Miles. |
| Cacequy to Santa Anna de Livramento....... | 98 |
| Margem to Montenegro .................. | 34 |
| Neustadt to Montenegro and Caxias ......... | 93 |
| Passo Fundo to the Rio Uruguay ........... | 112 |
| Santa Cruz branch ........................ | 19 |
| | 356 |

The system has been rather a costly one, owing to the quantity of bridging. But it has been most productive, and is worked at 60 to 50 per cent. of the gross earnings.

There is no all-absorbing traffic, as there is in the State of Sao Paulo, which is a good thing, as the company is not at the mercy of any single article. But some are preponderant, of course, and foremost among these are cattle and their subproducts.

THE PICTURESQUE SCENERY OF THE CAXIAS RAILWAY

The raising of cattle is still, as it is in Uruguay, the principal industry of the Rio Grande. This is illustrated by the fact that no fewer than 37,000 animals were carried in the ordinary trains in 1909, besides some 75,000 in special animal trains. The cattle, roaming in the practically uninhabited "campos," are in almost a wild state, and are not easy to handle. For this reason the cattle wagons are very different from those to be met in Europe. There are no side doors; instead of these, the end portions can be raised, guillotine fashion, thus forming a continuous corridor from end to end of the train. The cattle are driven into a large pen by the drivers (the Rio Grande "gaucho" being quite as skillful as the North American cowboy), and from this pen into a narrowing passage, which ends on a raised platform, up to which is backed the tail end of the cattle train. The animals rush blindly on and into the train, each door of which is closed as the corresponding wagon receives its full load. Any impediment, such as ordinary doors, would be almost impossible, which is the reason why these end doors have been preferred, the disadvantage of their weakening the wagons being infinitely less than would be the extra difficulty in the loading of any other system of car.

These cattle trains cover long distances, a very usual run being that from Tupaceretan to Pelotas, a distance of 403 miles. These trains are timed at passenger train schedules, and, as the oxen are only carried a few months in the year, this period (called the "safra") is a hard one to deal with. The large slaugh-

THE ONLY TUNNEL ON THE CAXIAS RAILWAY

ter houses, the principal of which are in Pelotas, Bagé, Dom Pedrito, Santa Anna, Santa Maria and Tupaceretan, turn out "jerked beef" in large quantities, which is then carried to the frontier for exportation all over Brazil. The other products, hides, bones, etc., add notably to the tonnage, which was 22,933 tons for the jerked meat, 14,681 tons of hides and 11,900 tons of other sub-products in 1909.

Another important class of goods is timber, carried from the wild forests of the upper Uruguay and of the Caxias district right through the State, a distance often exceeding 500 miles; 49,581 tons of timber were carried in 1909. The total goods tonnage was 345,930 tons.

Passenger traffic consists of first and second class travelers only, 522,919 in number, two-thirds of which travel first class. Dining cars are run on most trains and sleeping cars on the international night trains.

The goods wagons carry 16 tons, and the new ones will be of 24 tons capacity.

The passenger trains are timed at 28 miles an hour on a level tangent and the goods trains at 19 miles, with equivalent speeds on grades and curves. The actual running speed is, therefore, the same or greater than that of the neighbouring normal-gauge lines in Argentina and Uruguay.

As to the actual running, there are two difficulties to contend with which the European traveler does not know: cattle and locusts.

The cattle cannot be kept off the track. Miles and miles of it are fenced in, and yet the cattle manage to force their way through, and then cannot get out. The cow-catcher is efficient, but not sufficiently so, as the trains are often derailed by an ox being caught either between the cow-catcher or cylinder and the rail, or even between the locomotive and the truss of a bridge; but such accidents are hardly ever serious.

Locusts are less common, but occasionally travel along in clouds. When they come to earth they may pile up to a foot deep in the cuttings,

EMBANKMENT AND CULVERT ON THE CAXIAS RAILWAY

and, of course, the locomotives will skid along uselessly. This happens but infrequently.

The track is not stone-ballasted, except along a few sections. The sleepers are close, and, although made of untreated hardwood, they last a dozen years on an average. The new rails weigh 46 pounds and 60 pounds, respectively, the recent introduction of heavier plant having rendered a stronger track necessary.

The rolling stock includes 196 locomotives, 211 coaching stock and 1,927 wagons. They are provided with automatic "Henricot" couplers and fitted with the Eames non-automatic vacuum brake.

Up to 1906 most of the locomotives had been purchased from the Baldwin Locomotive Works. There were also some old French locomotives and a few English taken over with the older roads. Between 1906 and 1908 the Compagnie Auxiliaire purchased 67 locomotives from the Borsig Locomotive Works. This German motive plant is an innovation in Brazil, and the locomotives themselves quite worthy of note. In 1907 another batch of 27 locomotives has been added. These consist of ten-wheel locomotives and six powerful Mallet engines. The ten-wheel locomotives are fitted with Schmidt's superheater. The Mallets are compounds, and similar to those on the Sorocabana, though a little lighter, weighing, as do the ten-wheel locomotives, but 10 tons on each driving axle. Thirteen of the ten-wheel locomotives come from Borsig's, the remainder and the Mallets from Tubize, Belgium.

Before having brought these lines to completion further extensions had been thought of, and the company had surveyed the following:

| | Miles. |
|---|---|
| The Cerro Chato and Jaguarao branch....... | 66 |
| Santa Maria and Pelatos transit line........ | 225 |
| Passo Fundo Porto Alegre short line........ | 156 |
| Sao Sebastiao, Dom Pedrito, Santa Anna..... | 94 |
| | 541 |

But the Federal Government met with a good deal of opposition locally. The limits of Stadoal and Federal authority has never been very exactly defined. Tidal rivers are claimed by both. Thus, Porto

Alegre, though so far inland, could, at a pinch, be considered to belong either to "Stadoal" or "Federal" jurisdiction.

Finally, at the beginning of 1911 the Federal Government invited tenders for branches running to the frontiers, and which can be considered as strategical lines. These are the following:

Sao Pedro (on the P. A. U.) to Sao Borja (frontier), and a branch to Sao Luiz;

Alegrete (on the P. A. U.) to Quarahim (on the frontier):

Sao Sebastiao (near Bagé) to Palomas (near Santa Anna frontier);

Cerro Chato (on Bagé-Rio Grande) to Jaguarao (frontier).

The State also intends granting a short line from Passo Fundo to Lageado, on the Rio Taquary, whence steamers would ply down to Porto Alegre, and another from Bagé to that capital.

But as it is, the Compagnie Auxiliaire has not a monopoly.

We have seen that the Federal Government has conceded the Sao Paulo & Rio Grande Railway Company a line from Sao Francisco to Porto Alegre. This line skirts the sea coast and enters the Rio Grande at the port of Terres. This is a small place now, which it has often been thought expedient to turn into a harbour which would compete with Rio Grande. It could be joined easily by canal, through a series of lagunas and small lakes, with Porto Alegre itself.

The "Riaocho Railway," from Porto Alegre to Tristeza, is a municipal line, six miles long, worked by the municipality.

The Sao Jeronymo Railway is a mineral line, running from the river to that company's coal mines, some 13 miles inland. The concession was given in 1890, and granted a line from the Rio Taquary to some point of the Rio Grande & Bagé Railway, together with branches, altogether 328 miles, with a 6 per cent. guarantee. But construction has never been proceeded with beyond the original section.

The only line of some importance is the "Brazil-Great Southern." It was opened in 1887 and 1888 from Quarahim, at the southern frontier, to Uruguayana and on to Itaquy. Its 110 miles are laid close to the river bank, which explains the large amount of bridging. The longest of these is Liberty Bridge, over the Rio Ibicuhy. It is 3,970 feet long, with four spans of 225 feet in length. These rest on cast-iron columns sunk down to the rock level and lesser-diameter columns, above water, connected with them by a specially designed tapering section. The two companion columns of each separate pier are secured together by means of diaphragm plates. They are filled with concrete. This system of construction, much used on all South American railways, answers well, and is cheap.

The line has a Government 6 per cent. interest guarantee, which it has often been called upon to use, as it has seldom been a paying concern, though it has occasionally covered working expenses, particularly during the few years it worked the Uruguayana and Alegrete section of the P. A. U. Railway previous to December 31, 1907.

A further extension is building, called the "San Angelo Extension." The company is building the line between Itaquy and Sao Borja, and has right of preference for further extension northward. The cost of the works is paid for by the Government on a higher scale than that of the Compagnie Auxiliaire.

In 1907 the company owned 8 locomotives, 12 carriages and 114 wagons. Three ten-wheel tender locomotives have been added in 1910, built by Kitson & Co., Leeds.

(To be concluded.)

# MODELS OF VESSELS

## THEIR AESTHETIC AND SCIENTIFIC VALUE

By Chas. B. Brewer

OF the many things in Washington that attract to it its thousands of visitors, there is probably nothing that leaves its mark on the memory as do the display models of Uncle Sam's fighting ships to be seen in the corridors of the east or White-House side of the great State, War and Navy Building, often called the "greatest office building in the world."

These models are not at home all the time, however; for, like their prototypes after an extended stay in port, the spirit of unrest of all things associated with the sea seems to possess them, and off they cruise (if we may take a liberty with the word) to some exposition at St. Louis, Jamestown, Portland, and, most recently, the Appalachian Exposition held at Knoxville, Tenn., in September and October. Anomalous as it may seem for ships to travel by land, these models are great globe trotters, and some have traveled far enough to have more than encircled the globe.

The latest additions to the "fleet" of models is the magnificent new model of the *South Carolina,* which vessel distinguished herself by making the marvelous record of sixteen bull's-eyes out of sixteen shots, all in less than five minutes, and a total of fifty-five bull's-eyes out of sixty shots, three out of four of her turrets having made 100 per cent. of hits.

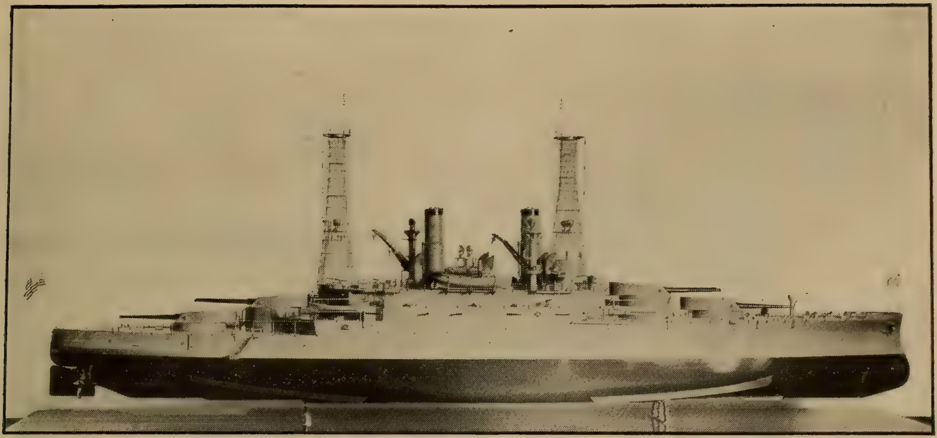
In order that the model might, in all visible respects, be a true representation of its prototype, its completion, as is usual, was delayed until after the vessel proper was finished.

The *South Carolina* and her sister-ship, the *Michigan,* are only so-called "semi-Dreadnoughts," but they, together with the *Delaware* and *North Dakota,* are the most powerful of any of the United States vessels yet completed, and have been credited by more than one of the British journals with being the equals, if not the superiors, in broadside fire of any "Dreadnought." So, also, their model, shown in one of the photographs, is more pretentious than any of its predecessors.

This wonderful example of the craftsman's skill has all of its details just one-forty-eighth of their originals in size. A comparison of volume between the original and model would, therefore, be represented by the cube of forty-eight, or, to put it in more tangible form, the real *South Carolina* could stow away over 117,000 of its models, if it were possible to pack them without loss of space.

In the reproduction of all the parts which the eye can see the model-maker has used the working drawings of the ship. The shape of the hull has been accurately reproduced from lines taken from the "mould-loft" where the real vessel was laid down. Its fore-and-aft body has just the "run" of the big ships' lines, the "midship section" just the proper outline, and its rudder has the exact shape and proportionately just the correct area of the vessels that are now carrying nearly a thousand souls.

As on the vessels proper, the most striking features of the model are its *two* 12-inch turrets at *each* end, with the guns mounted partially over



DISPLAY MODEL OF UNITED STATES BATTLESHIP SOUTH CAROLINA

one another, and its fire-control towers, or the "waste-basket cage masts," as they are popularly known. The 80 or more feet that the top platforms of the towers are above the decks of the vessels is reached in the model by wires about a foot and a half long and considerably smaller than the lead of an ordinary pencil. Like the tubing of the real towers, these wires, to give strength and rigidity, are carefully secured to one another wherever they pass. The platforms of wire netting, the ladders, the searchlights, and various other features are accurately portrayed.

The sullen slate or "war colour" paint covers all parts of the model which will be visible in the vessel when afloat. Even the tiny models of the various types of the ship's small boats are so coloured. Standing close beside the glass case which encloses the model and looking down may be seen the light colour of the weather decks. The war colour is broken elsewhere only by the shin-

A GROUP OF YACHT MODELS

ing metal of the vessel's propellers and two bundles of tiny oars lashed in the cutters and lifeboats. These little "lifeboats" are shown hanging at their davits abreast the after-tower as if at sea and ready to be instantly dropped at the cry of "Man overboard!"

As wonderful as the little boats appear with their seats, gratings and other fittings, all together not much larger than a man's finger, the tiny oars referred to are wonderful in themselves. Though perfectly shaped and finished, they are only about as large as an ordinary wooden toothpick.

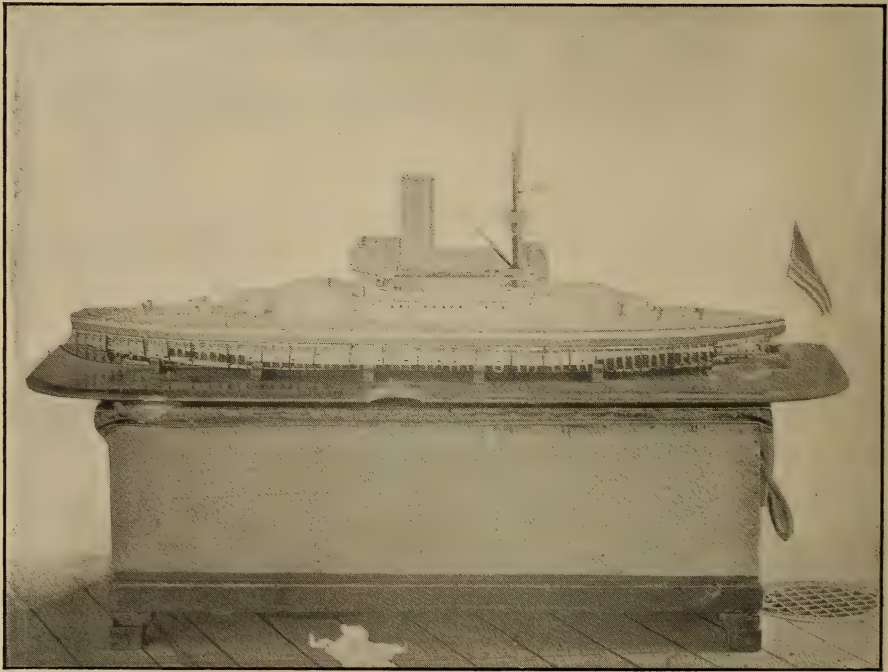
The hook of the forward boat crane, capable of lifting a 30-ton test load on the ship, yet in the model about the size of an old-fashioned earring, may be noted hanging in an unnatural position, the drum of the motor having drawn too tightly

The stays to the topmasts and the smokestack guys, representing about all the rigging left in these days of steam, have been taken from a spool of cotton, and are so fine that some of them do not appear in the photograph.

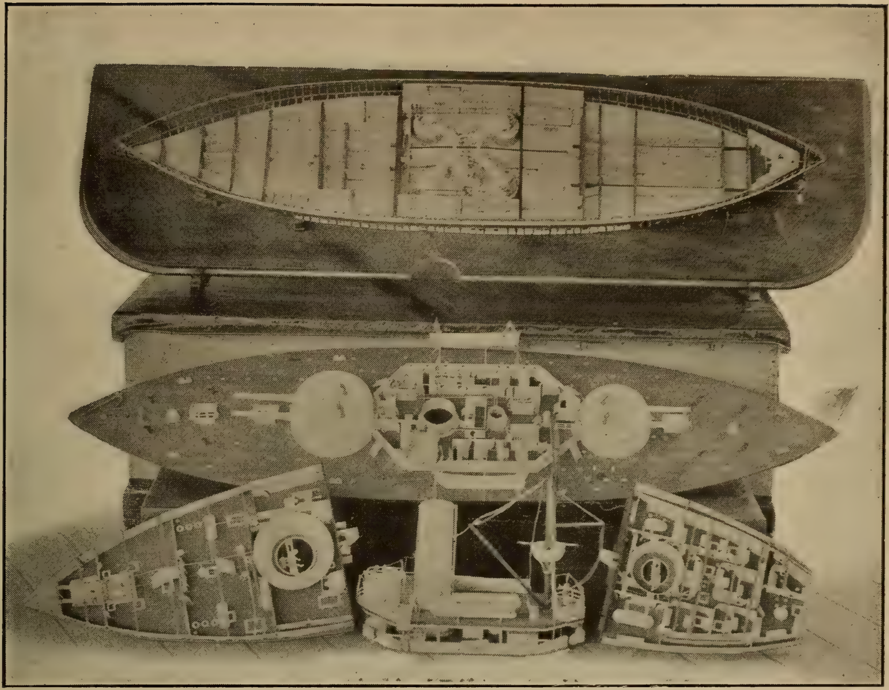
The Ardois or night-signaling sets are visible hanging from the top of the forward cage mast, as are less distinctly the four minute metal strands stretched between the topmasts to represent the "wireless."

Eight searchlights may be readily recognized in the photograph, two on each tower, one on each boat crane and two on special platforms. So conscientious has the model-maker been in depicting the various parts that the glass of the 30-inch searchlight, which appears in the model the size of a 10-cent piece, has been shown in its dozen or more divisions, as if to provide in the model, as in the real searchlights, a ready and inexpensive means of substituting a broken part.

The craftsman has so perfectly shaped the big guns, the rapid-fire and field guns with their carriages,



SKELETON MODEL OF UNITED STATES MONITOR MONTEREY



SKELETON MODEL OF THE UNITED STATES MONITOR MONTEREY

the awning stanchions, the life-lines, the air-ports, the decklights, the boat and propeller booms—in fact, the thousand-and-one bewildering details—that the observer, in studying them, forgets that he is not looking on the real man-of-war. He forgets to wonder with what sort of an instrument the delicate life buoys could have been fashioned, the ship's winches brought into workable shape, and how it has been possible to shape the tiny square holes in the landing gratings of the sea ladders—little squares so perfect and yet so small that a pin could not be pushed into them. So natural does it all appear that one almost expects to hear the little ship's bell in the forward tower ring out its summons and see a lot of little blue-jacketed pigmies of the miniature ship's company, sea legs and all, come waddling over the decks in answer to its call.

This model has cost some four thousand dollars. Few there are, though, who would begrudge the cost, could they see the interest taken in it by the thousands from all parts of the country who have helped to pay for it, and many of whom have never seen one of the vessels themselves. There are some who call these models toys. Yes, they are toys—if great paintings are toys.

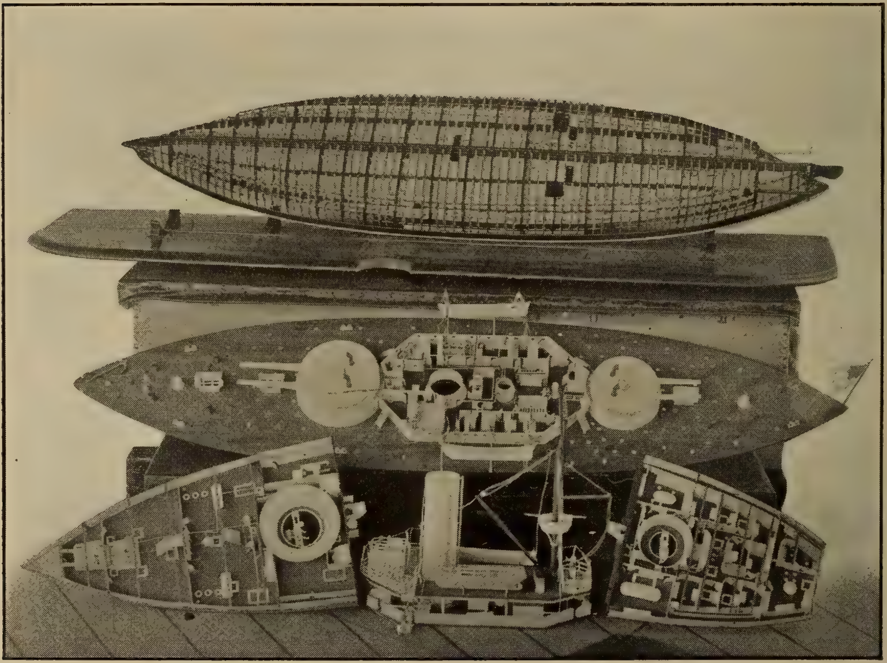
### SKELETON MODELS

Less beautiful, but more useful than the display model, is the skeleton model, made for the purpose of showing the interior construction and the machinery of the vessel and used to great advantage in quickly familiarizing the sailor with his ship, where days and sometimes weeks, of study are required, even when he is able to read drawings.

All of the framing and plating of the decks, bulkheads and inner bottom and other longitudinal and transverse framing are shown in their true relation to one another, and their relative importance on structural strength and water-tightness portrayed. The skeleton model is so constructed that it may be taken apart in order that the interior may be more readily visible and that every nook and corner of the vessel may be revealed to the observer.

The first skeleton model that came to the notice of the writer was carried by a German cruiser. All the sailors had ready access to it, and the ordinary seaman who showed me over the vessel, in taking it all apart, named with surprising accuracy all the intricate parts and compartments of his vessel. In keeping with the German character for thoroughness, it is the practice of their navy to carry one of these skeleton models on all of its naval vessels for the education of its seamen. They cost anywhere from $500 to $2,500, dependent on the size and type of the vessel.

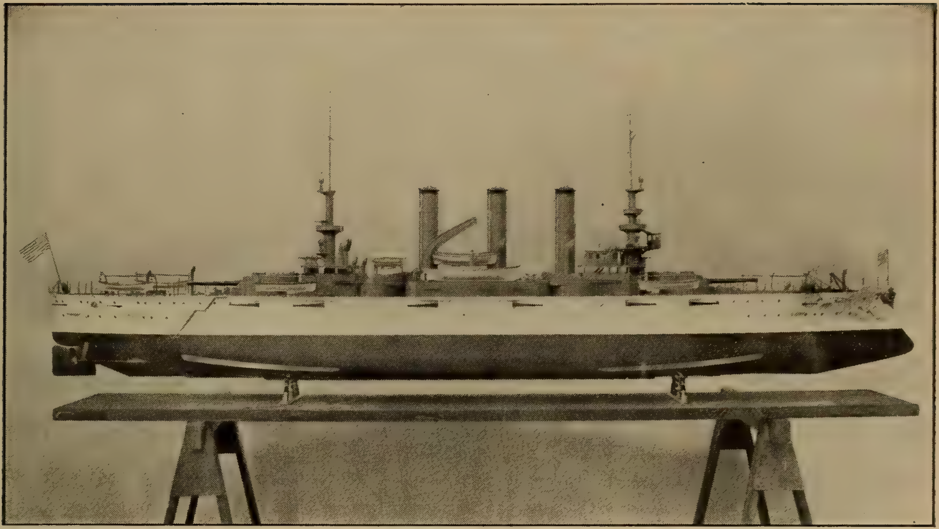
From these models the outer skin of the vessel is usually omitted, but they are made with all the watertight floors sub-dividing the inner bottom and the bulkheads marking the larger sub-divisions of the vessel. The engines, boilers and much of the piping, as well as the various watertight doors and manholes, are also portrayed. The models can thus be used as a guide for access to remote corners of the vessel obtained by tortuous routes and sometimes not visited for months. They are used, too, as a means of readily ascertaining the full effect on the vessel of a puncture of the armour by a lucky shot or a tear in the vessel's shell by grounding, and can also be used to impress upon the sailor the value of eternal vigilance in keeping his watertight doors closed and secured, or "dogged," in seaman parlance.



SKELETON MODEL OF THE INSIDE VIEW OF THE UNITED STATES MONITOR MONTEREY

By W. H. Beehler, U. S. Navy

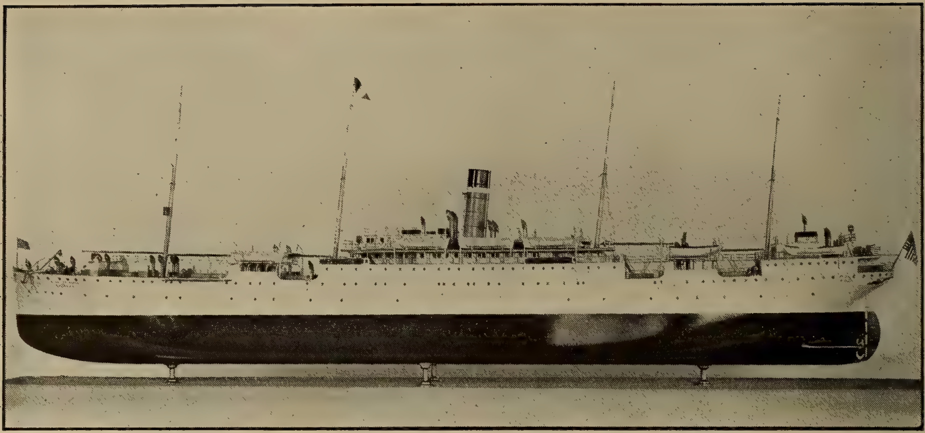
Some of the photographs show



DISPLAY MODEL OF CONNECTICUT, BROADSIDE VIEW

the skeleton model of the U. S. monitor *Monterey,* published through the courtesy of the Naval Institute and Commodore Beehler, U. S. N., who tells an interesting story about the construction of this model. When serving as naval attaché at Berlin, he noticed the practice of the Germans to supply their vessels with skeleton models, and suggested it be done in our service. There was no appropriation available and action on the suggestion was deferred. Commander Beehler, as he then was, was soon after this ordered to the Asiatic Station in command of the

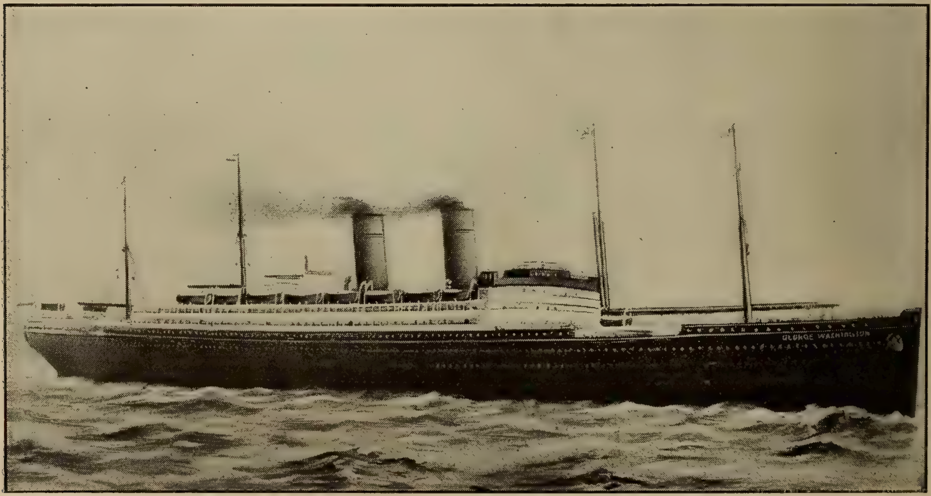
DISPLAY MODEL OF CONNECTICUT, THREE-QUARTER VIEW



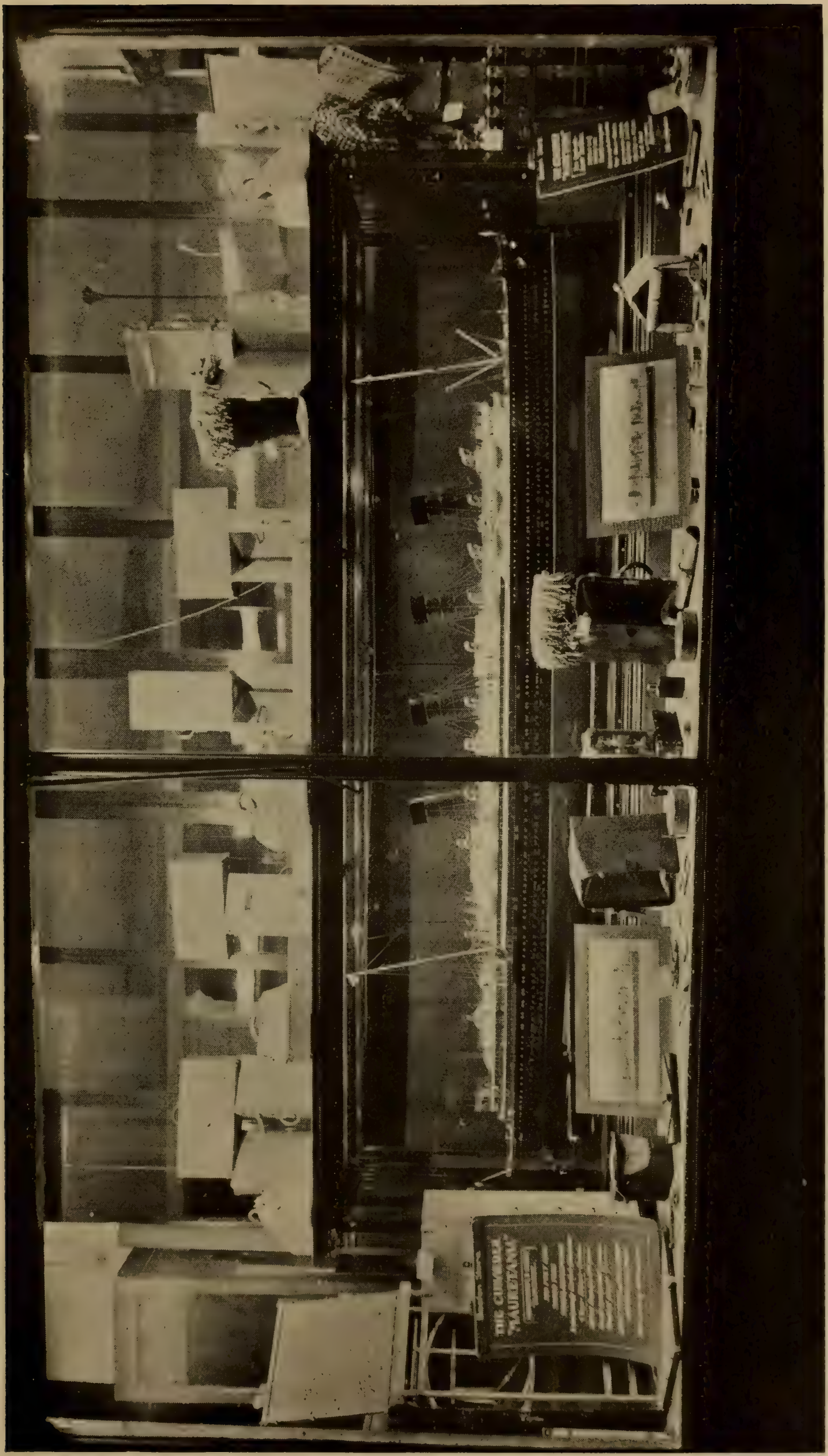
SKELETON MODEL OF UNITED STATES ARMY TRANSPORT SHERMAN, EXTERIOR VIEW

*Monterey*. When in Hong Kong, he found a skillful Chinese carpenter, who was willing to undertake, at comparatively small expense, the construction of a skeleton model of the *Monterey*. He used principally wires, cardboard and wood in its construction. The model was nearly completed, but some of the piping showing how certain compartments were drained and pumped out had not been put in when the vessel was ordered away. It was suggested that, in order to save time, putty be shaped into representation of pipes, and in this way quickly finish the work. The ingenious Chinaman *heard* the suggestion. Before the vessel sailed he was ready, and turned over the model with the pipes in question accurately represented, even to being painted the various colors customary in the service to readily distinguish them. The pipes, however, were made, not of putty, but of macaroni.

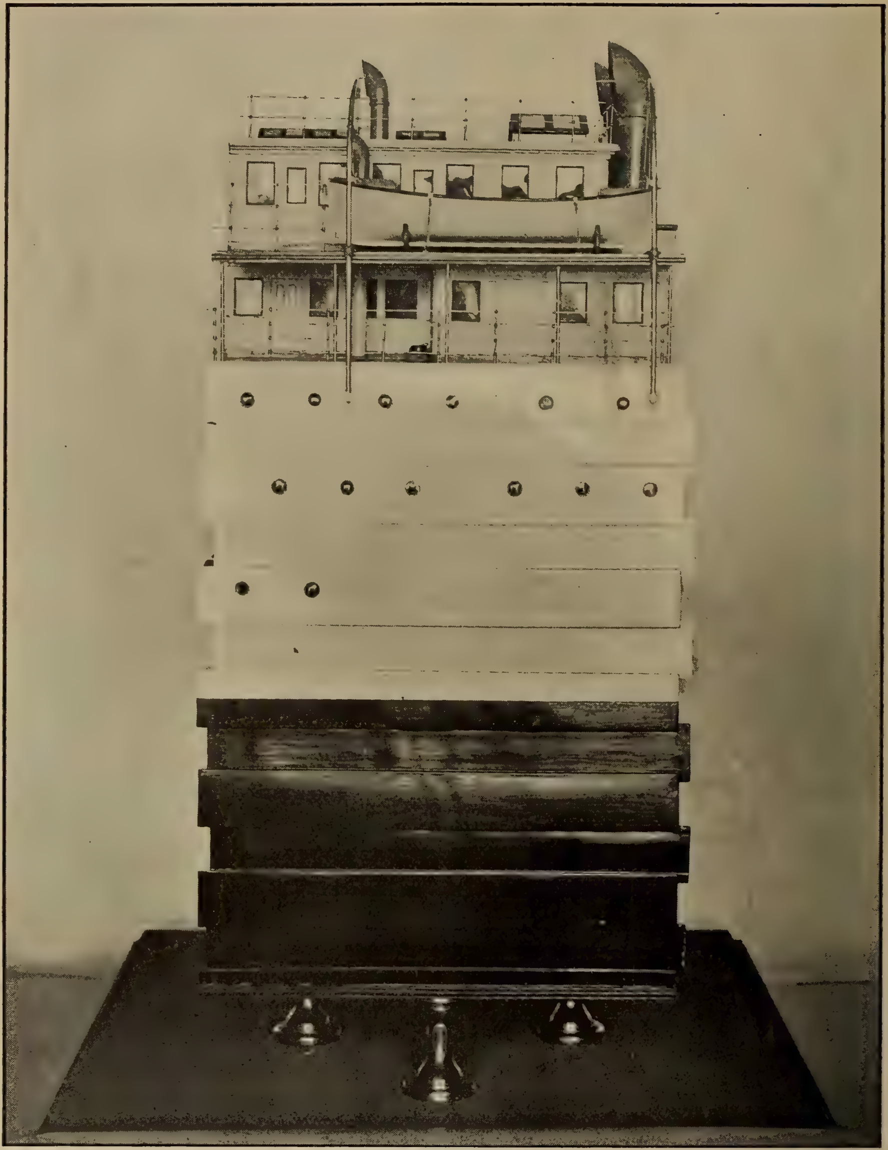
This model of the *Monterey* was made entirely in the captain's cabin of the vessel, in order that the plans of the vessel should not fall into un-



MODEL OF THE GEORGE WASHINGTON, NORTH GERMAN LLOYD STEAMSHIP COMPANY VESSEL, 722 FEET LONG, 37,000 TONS DISPLACEMENT, 20,000 HORSE-POWER



MODEL OF CUNARD LINER MAURETANIA, SHOWING THE MANNER IN WHICH SUCH A MODEL IS USED FOR EXHIBITION PURPOSES. VESSEL 790 FEET LONG. SPEED 26.06 KNOTS



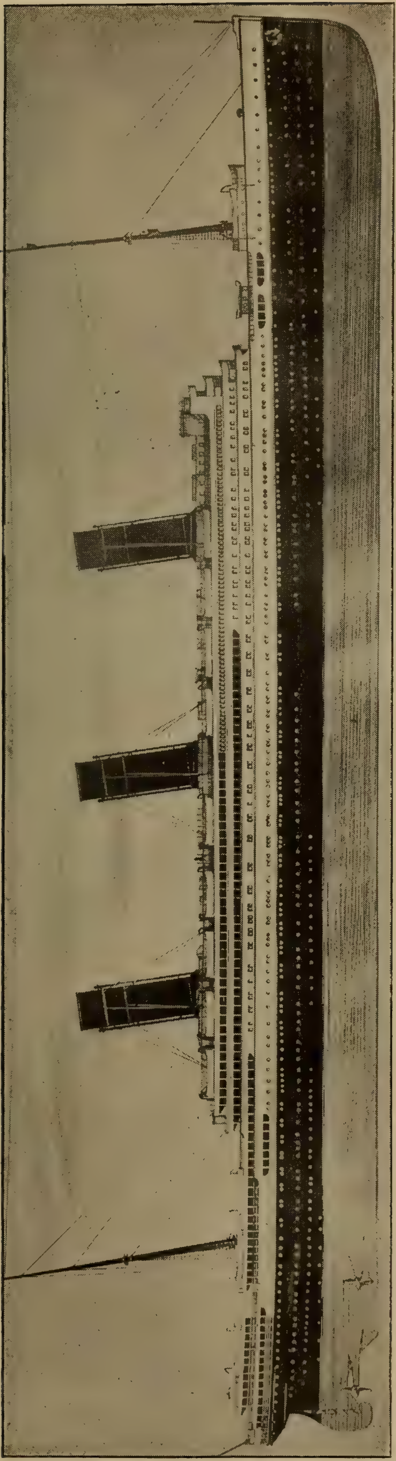
SMALL SECTION OF SKELETON MODEL OF U. S. ARMY TRANSPORT SHERMAN

authorized hands in a foreign country.

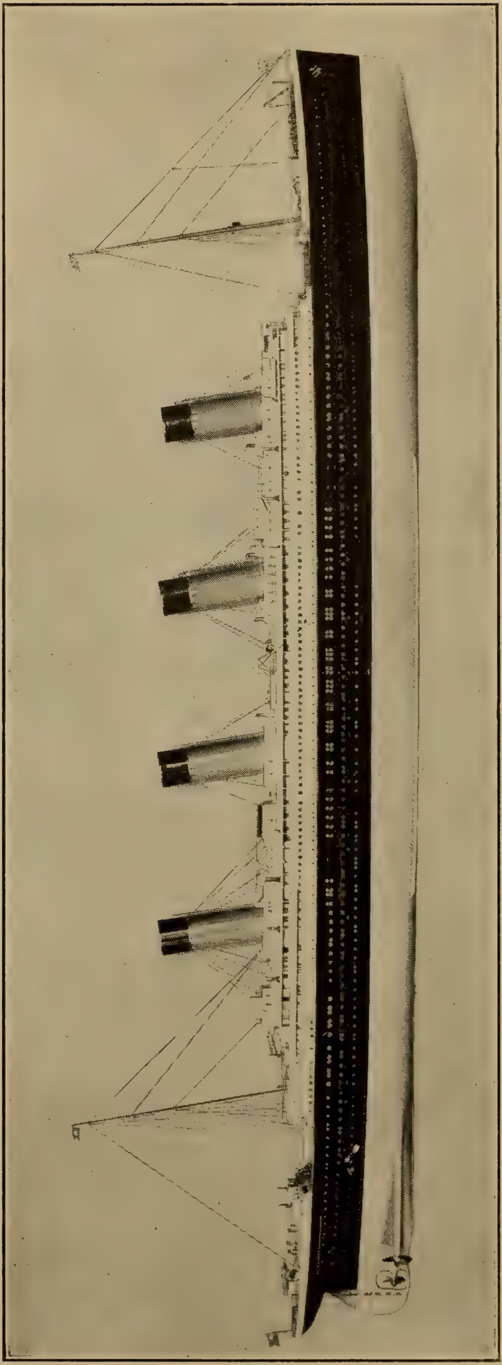
Commodore Beehler has informed the writer that his experience with this skeleton model had confirmed his opinion that it has no equal as a means of familiarizing a ship's company, both men and officers, with their vessel.

The *Monterey's* model was subsequently sent to the Naval Academy, Annapolis, and used for the instruction of the midshipmen.

Probably the most complete example of a skeleton model ever made is that of the army transport *Sherman,* made at the New York shops of H. E. Boucher, who was for a long time in charge of the model work at Washington Navy Yard, and under whom were fashioned



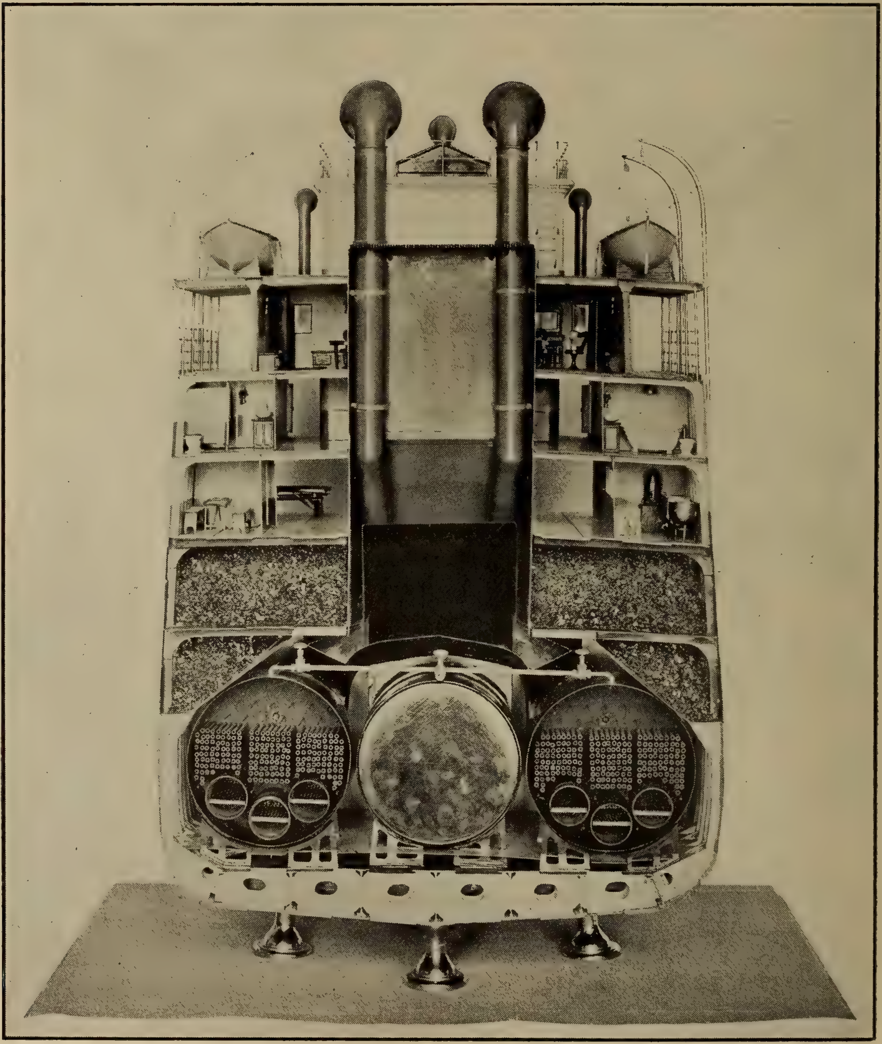
MODEL OF THE NEW HAMBURG-AMERICAN LINER EUROPA. VESSEL 900 FEET LONG, WITH 50,000 TONS DISPLACEMENT



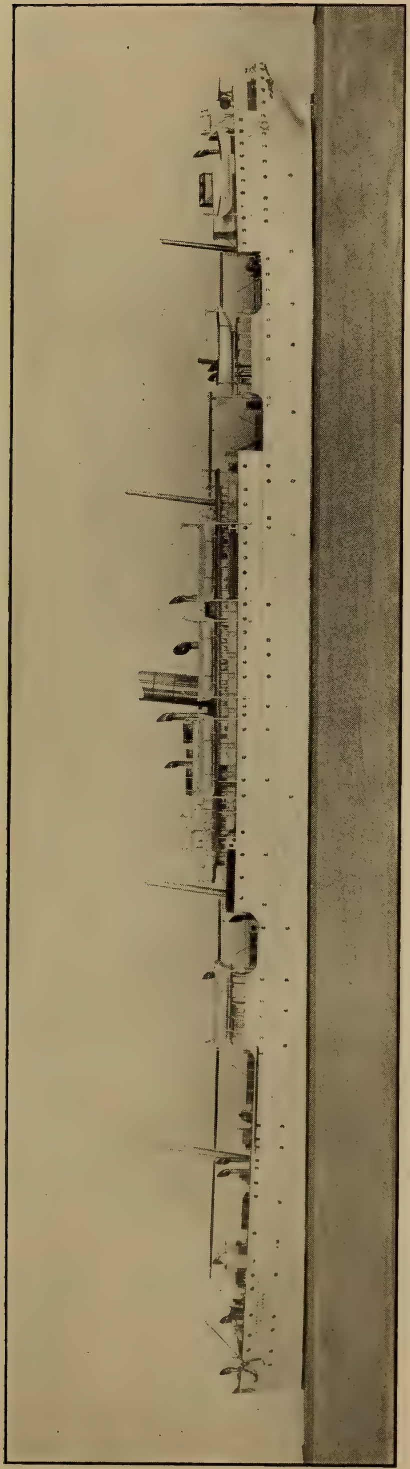
MODEL OF WHITE STAR LINER OLYMPIC, ONE OF THE MOST EXPENSIVE MODELS MADE, COSTING $12,500. THE MODEL IS 20 FEET, 6 INCHES LONG many of the creations in the navy collection.

This model of the *Sherman* is made up of about 10,000 separate parts, though its total length is only about 12 feet. The vessel proper is arranged with 1,800 bunks, with all the culinary and other housekeeping arrangements to accommodate that many troops. Imagine the patience required to properly place these details in the model and arrange to make all the bunks and several other thousand parts of the model removable! The home of this model is in the War Department side of the State, War and Navy Building, where the navy's display models are kept.

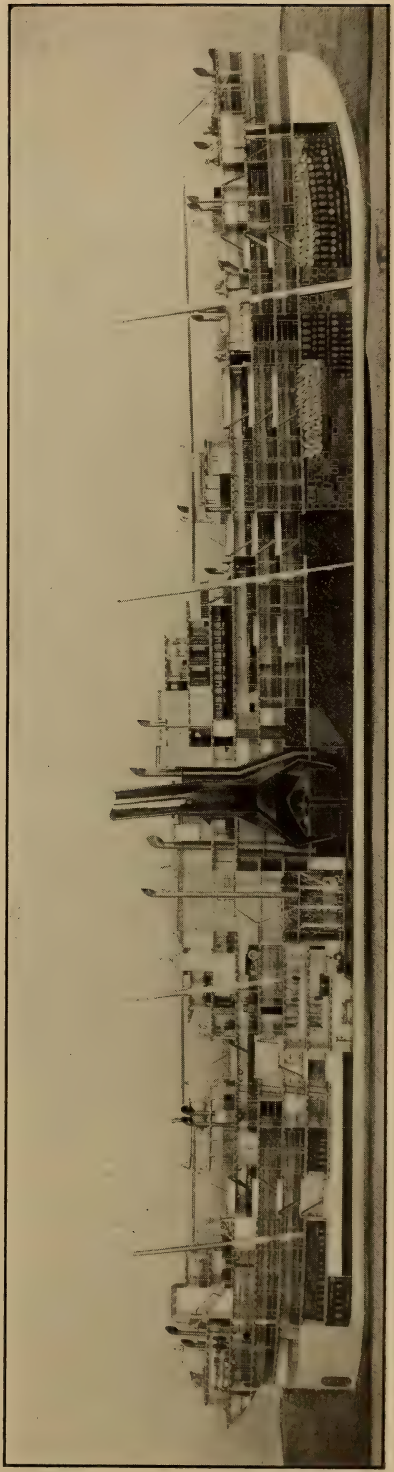
Though established only a few years, the shops of the Boucher Company, where the *Sherman* model was made—which is the only place of the kind this side of Paris—finds enough work of this kind to keep fifteen skilled workmen busy, although the many castings that are needed are made under contract by outside foundries. Another example of delicate work of model-making is illustrated in the photograph of a



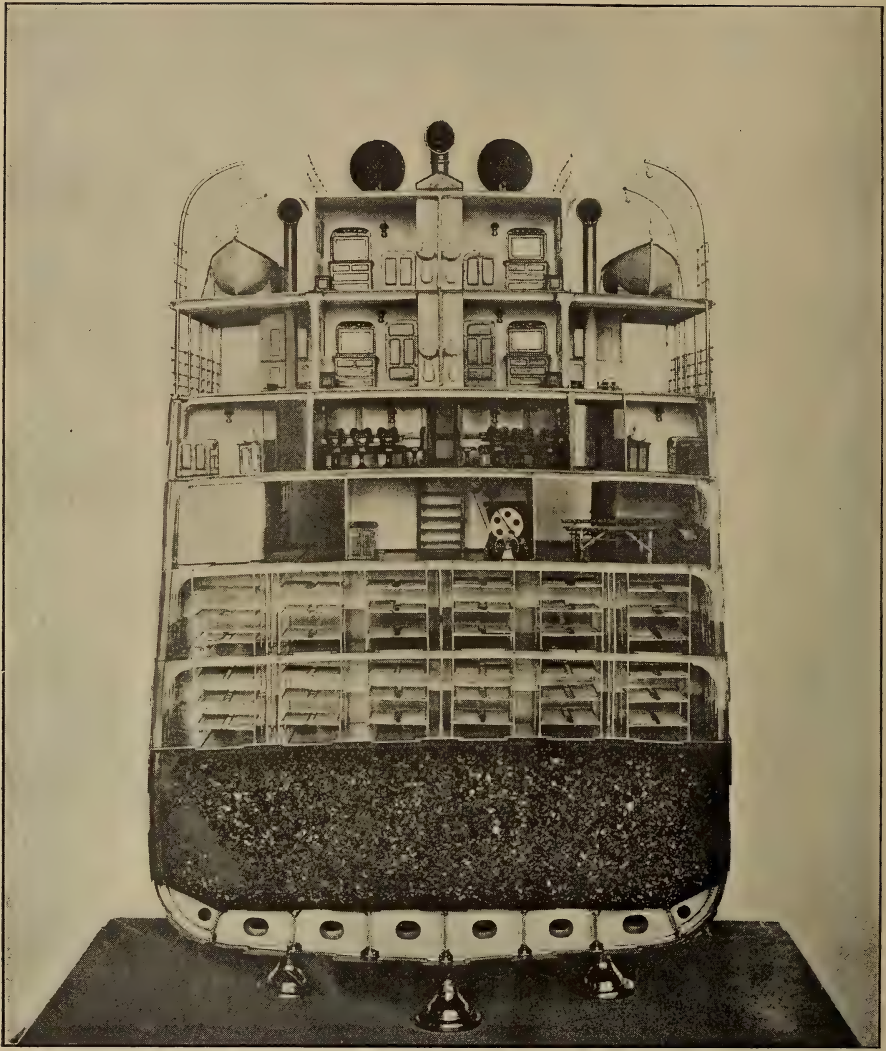
SKELETON MODEL OF ARMY TRANSPORT SHERMAN, SHOWING SECTION OF SHOW BOILERS, COAL BUNKERS, ETC.



SKELETON MODEL OF UNITED STATES ARMY TRANSPORT SHERMAN, REPRESENTING SHIP IN WATER



HALF OF THE ABOVE MODEL, SHOWING INTERIOR LONGITUDINAL VIEW

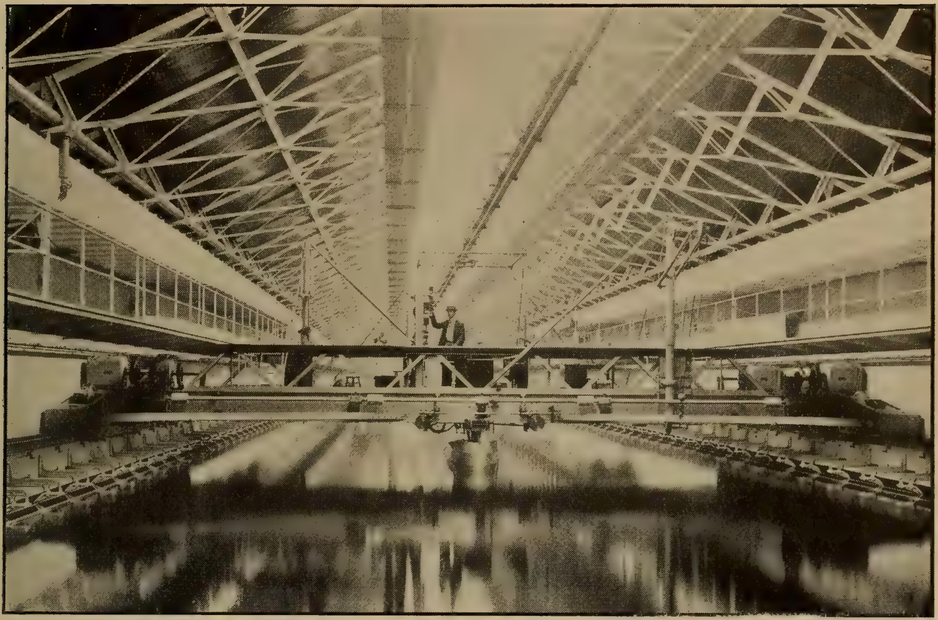


SKELETON MODEL OF ARMY TRANSPORT SHERMAN, SHOWING LOWER COAL BUNKERS, STATEROOMS AND QUARTERS FOR SOME OF THE 1,800 TROOPS

group of yacht models made by this firm.

FORM, PLATING AND SPEED MODELS

For generations shipbuilders have made use of models for the final determination of ships' forms. The utmost care is taken to reproduce in the model the designed lines of the vessel. The model is then turned over to the company's expert, whose trained eye and hand quickly determine whether there is "unfairness" anywhere in the proposed shape of the vessel. The sense of touch in detecting surfaces that do not form graceful curves which will glide smoothly through the water becomes highly developed in these experts. It has been developed to a degree that is remarkable at the famous Herreshoff plant, where it has for a long time been *solely* relied upon by giving the final say on the form of the yachts built by that firm into the hands of one of the brothers



EXPERIMENTAL MODEL BASIN, WASHINGTON, D. C., NAVY YARD, READY FOR THE RUN

who long ago lost his eyesight. And this is the firm, it will be remembered, that has built several of America's cup winners.

Formerly a good shape for speed would be secured by a shipbuilder after a long, hard-fought experience, and this shape would be clung to. Changes in size to suit the purchaser would be obtained by

EXPERIMENTAL MODEL BASIN (SPEED TRIAL UNDER WAY) AT THE WASHINGTON, D. C., NAVY YARD lengthening, shortening or otherwise changing the model, but the same general features would be adhered to.

After serving the first purpose, these models can be used as "plating models" to lay off the "strakes" or layers of plating, the vertical and horizontal framing, etc., and to see that their joints are well clear of one another, in order that no line of weakness may occur in the vessel.

It has been known by shipbuilders for a long time that increased speed could be obtained on the same horsepower by lengthening a ship, even though the total displacement, or weight, of the vessel were increased. There was no known way, however, of determining just how much it should be increased to produce the best results until the advent of the experimental model basin.

### EXPERIMENTAL MODELS

The experimental model is not so familiar to sightseers in Washington as is the display model, and is, perhaps, of less interest to laymen; but they are by far the most valuable of any of the various kinds of models from a scientific and practical standpoint. They are used in the experimental model basin for determining with nicety the horse-power which will be required and the most efficient length and form for new designs of ships.

At one stroke these models, or, more properly speaking, the experimental model basin, eliminated guesswork from the designing of ships' forms and placed into the hands of the naval architect an exact miniature, which, if followed, will meet any desired condition. At the same time, it placed at the disposal of the marine engineer information to enable him to determine precisely the size of his engine or turbine, his auxiliary machinery, and at what speed his propellers must turn.

The experimental basin at the Washington Yard was finished in 1899. A series of experiments soon after its completion demonstrated most clearly its great practical importance. The length and form of the six battleships of the *Virginia* class, representing an outlay of thirty million dollars, was under consideration. The shape and dimensions determined upon by its use were such that the completed vessels developed more than their required speed of 19 knots on 2,000 less horse-power than would have been required by the first set of lines, representing a total saving in the coal bill of nearly a thousand dollars a day when steaming at full speed.

The model basin is 500 feet long and holds about a million gallons of water. It was the fourth built in the world, then the largest, and though there are now nine such basins, some slightly larger, it probably is still the best equipped in the world.

The water is supplied from the city supply, and a small stream is kept constantly running to keep the tank fresh. All the water is treated with alum and filtered, in order to keep it clear and at an exact specific gravity, so that the resistance may be measured with precision, as any error would be multiplied many times.

The models used, one of which is shown in a photograph, are 20 feet long. They are carried through the water by an overhead electric carriage mounted on rails, which accurately measures the resistance at any desired speed, ranging from one-half knot to a maximum of 20 knots.

Private shipbuilding plants are accorded the privilege of having their models tried at the basin at a small cost, and many have taken advantage of the privilege. The basin has thus contributed largely to the advancement of the mercantile marine, in addition to the immeasurable advantage it has been in the design of naval vessels.

# THE GREAT TRANSFORMATION

**By Henry Harrison Suplee**

"Find out which way the procession is going, and get in front."

## INTRODUCTION

The series of articles of which this is the first covers a view of the changes which may be expected in consequence of the rapidly extending control of mankind over the dominion of the air. It is not intended to examine the detailed construction of the machines themselves, nor of the steps in the progress of aerial navigation which must lead up to the general control of travel and communication through the air. These will follow the present methods in the natural course of mechanical evolution, and hence it is intended at the present time to examine rather the modifications which must result from the command of the space above the surface of the earth. The present article is, therefore, only a preliminary view of the fundamental changes which must follow the success of man in overcoming the disadvantages under which he has been labouring until now; giving an impression of the basis upon which modifications of life upon the surface of the earth must soon be expected to depend.

BEFORE examining closely the great transformation which is impending as a consequence of the conquest of the domain of the air, it is desirable to consider some of the transformations which have already been effected by other developments in the art of directing the great sources of power in Nature to the use and convenience of man.

The perfection of the steam engine by Watt and his followers caused the entire transformation of manufacturing operations in a period of about fifty years. Individual methods were almost wholly replaced by factory systems, apparatus developed and applied which would otherwise have been unworkable, and new wealth created to an extent almost incalculable. This, in the space of an average lifetime, against the desires, predictions and belief of contemporary individuals of high intelligence.

The application of the steam engine to navigation by Fulton transformed commerce, warfare and personal transport. In less than a generation from the first trip of the *Clermont* the Atlantic had been crossed, the Great Lakes navigated, and the rivers of the world converted into highways. Had Napoleon listened to the offer of Fulton the history of Europe might have been changed and Waterloo unknown. The time occupied in this transformation was about one-half that required for the steam engine; the consequences fully as far-reaching; the incredulity of the contemporary public as great.

The introduction of the steam locomotive transformed the face of the civilized world. This, a still greater change, took a still shorter time; and from the triumphant run of Stephenson's Rocket at Rainhill, in 1829, to the active spread of railways in England, America and the Continent, took less than fifteen years. By 1844 American locomotives were running in Russia. This marvelous advance also made its way in the face of stubborn conservatism and opposition.

Within the past decade we have witnessed yet another transformation—the introduction of the automobile. The horse, for thousands of years the main dependence for individual transport, is being replaced everywhere by the machine, and the streets, highways and countryside filled with swift, powerful and luxurious power vehicles. The derisive cries of the public have scarcely died away, and yet to-day there are millions of capital invested in automobiles and millions more in manufacturing plants.

Now, the curious thing about these momentous changes lies in the fact that they do not seem to have been grasped at all by the everyday world, and were certainly far from being realized by those among whom they were taking place. The writer has conversed with a man who talked with James Watt, and who saw the Rocket on the Liverpool & Manchester Railway. Within the span of that single life the whole face of the earth has been transformed by steam engine, steamboat, steam railway and motor car, and we have let these things sweep by us with but a faint perception of their mighty influence.

To-day we are in the midst of a still greater transformation, and this time not upon the surface of the earth, but above it. Its progress means almost unthinkable changes in commerce, government, warfare and daily life; and these changes are inevitably coming with a rapidity far greater than any of their predecessors.

Things move swiftly nowadays, and the novelty of to-day becomes the commonplace of to-morrow. Let us look ahead—not far into the future, but only as far as to-morrow—and endeavour to see what is there awaiting us.

## I.—THE FREEDOM OF THE AIR

There have been many definitions of "Property," each based upon some different phase of human ownership of material things, and each being the outgrowth of the ever-changing conditions of existence. Among these, one of the most recent and far-reaching is that which describes property as "that which one is in a position to defend."

All existing titles to ownership in land are traceable back to some individual or power, which, having taken possession of the territory, has parceled it out to retainers or followers, who, in turn, have transmitted their titles to their successors, to be passed on, divided up, united, transformed, according to the position in which the various owners found themselves. The ability to defend the title appeared sometimes in the ability to hold the land by appeal to law, a law which had back of it the power to enforce its decrees; sometimes in the ability to drive off the trespasser by force of arms; sometimes in the ability to circumvent the intruder by that skill and cunning which are often the most effective of all weapons.

When, as in the case of national and international upheavals, the whole fabric of society was overturned, the property came into the hands of those who were able to take it, from those who were no longer able to defend it, and the whole panorama which spread itself before the intelligent and thoughtful student of history reveals phase after phase of such wholesale transfers of property, due to the changing ability of the holders to defend the portions which were in their hands.

These considerations apply especially to property in land—that is, to portions of the surface of the earth. They assume, what has until recently been the acknowledged fact, that man has been able to control only the surface, that he exists practically in but two dimensions, and that his ability to defend the land really constitutes his substantial title. Even this statement is subject to limitations, since three-fourths of the surface of the earth, being covered with water, is not capable of local defense, and has been practically yielded to general ownership and released from individual proprietorship; and thus we come to the conditions which obtained until the present time—namely, that the greater part of the surface of the land portions of the earth is property solely because those who hold it can maintain their hold, because, so far as the land is concerned, the situation is that expressed in—

> "The good old rule, the simple plan,
> That they should take who have the power,
> And they should keep who can."

History has thus shown us how the property on the surface of the earth has been taken up, but it fails to reveal how anyone may seize upon the domain of the air. Already the air has been invaded by the amateur in radio-telegraphy, and the helplessness of the would-be authorities is almost ludicrous; the air is something which they are not in a position to defend, and property claims cannot be made good.

The legal mind naturally turns to precedent, and thus precedents may be sought in the rules which control movements upon the sea. The oceans, however, are limited by coasts, beyond which shipping cannot pass, and at which vessels are met and compelled to give account of themselves. The ocean of air by which we are surrounded and beneath which all our precedents have been formulated, has no such limitations, and its freedom to all must be conceded, however undesirable such license may appear. The irresponsible automobilist who runs you down and runs away is limited compared with the airman who may escape in any one of three dimensions.

We must concede, therefore, that the domain of the air represents, in the broadest sense, universal freedom—freedom for the airman to go and come as pleases him, regardless of the limitations which may be imposed on any portion of the surface of the earth. The word "domain" is almost inapplicable to this state of affairs, and the expression "freedom of the air" may be more properly used to describe it.

We shall examine in detail hereafter just what this kind of freedom will mean in different phases of human existence; but it is important, in starting, to grasp fully the limitations, not of the aerial world, but rather of the application of existing methods of regulation to its control. It would not be difficult to enact statutes regulating what may and may not be done in the air, but the matter of the enforcement of such statutes becomes an altogether different matter. The ignorant countryman who brings out his gun to shoot the balloon which is drifting over his farm is not far removed in his grasp of the subject from the French peasants of a hundred years ago who attacked the descending Montgolfier with flails and pitchforks; certainly neither line of action represents the sober sense of an intelligent community.

That control and regulation of some kind will be exerted must be admitted; but it will be regulation based upon the changed conditions, and a control derived, not from precedents which have little or no analogy, but rather from methods which will demonstrate their ability to defend themselves.

Therefore, one of the fundamental elements of the great transformation is the modification which is appearing in property rights. The owner of a house and farm may put his sign by the roadside, forbidding trespassers, and be wholly within his rights. The airman, at the same time, serenely passes directly overhead, choosing his own highway in the air, without so much as saying "by your leave." The so-called private grounds lie spread out to view beneath, and may be examined, photographed, and even surveyed from above, while the owner is either ignorant of the intrusion or powerless to prevent it.

The old idea that property rights extended up to the heavens has thus been modified, both in the case of radio-telegraphy and of aerial navigation. Just how high or how low the airman may fly remains to be determined. If the precedent of the automobile goes for anything, it will probably appear that the man in the air will take his chances of collision with chimney or cornice as recklessly as the man in the motor now skims across the railway or turns the close corner.

As with private property, so with public regulations. Since there is no highway marked out in the air, nor any method for compelling the aviator to keep to any particular route, such things as "rules of the road" may be invoked only when collision or other disaster places the man and his machine in the power of the official. Apparently the only manner in which authority may enforce any statutes regulating the conduct of the man in the air will be to catch him when he comes down to the surface of the earth, and in most instances the official will be obliged to take refuge in a ponderous indifference, much as the heavy policeman treats the jeers of the naughty little boys who can evade him with mosquito-like agility.

The difficulty of identifying the owner at once appears, and some better plan than the use of individual numbers will have to be devised for a machine which is traveling at a rate of 90 miles an hour at an elevation of 10,000 feet above the surface.

Broadly, then, we see that the addition of a third dimension to the space for man's activities practically furnishes new scope for action which lies almost wholly beyond existing methods for regulation or control.

The surface of the earth was taken up at such an early period of man's history that very crude methods were at first adopted, and the exploitation of the world has been extended over such a long space of time that there have been almost indefinite opportunities for adjustment and readjustment, and for the creation of a mass of precedents. When we consider, however, that the whole domain of the air is being thrown open at once, not to a few comparatively ignorant aborigines, but to the intelligent population of the civilized world, equipped with technical experience, training and skill, provided with all the resources of concentrated capital and control of appliances, and that the opportunities are being seized with avidity, the possibilities of the situation may be dimly realized. Since no analogy appears which is comparable to that of the exploitation of the surface of the earth by individuals, and since there exists an almost endless superposition of routes through the air, any control which is at present conceivable must lie in superiority of apparatus, or possibly in promptness in occupying the field.

Again, endeavouring to discover some precedent from past experience upon the sea, it may be recalled that even so comparatively simple an undertaking as the blockade of a coast has been found an extremely difficult achievement. When it is attempted to patrol and guard any portion of the aerial space the extension into the third dimension, demanding innumerable layers of sustained and hovering guard ships, reveals itself as obviously impracticable. The only manner in which man has successfully fought the mosquito has been by preventing its production, and not by combating it in the air. Long ago the reach of aerial navigation was observed, and it was remarked that the only way to retain control of a country under such conditions would be to roof it entirely over.

It may be said that conditions of existence upon the surface of the earth, with the air above free to all sorts and conditions of flying machines, would become unendurable. Probably this is also what would have been said, not by our ancestors, but by ourselves, some fifteen years ago, could we have foreseen the danger to which the foot passenger is exposed even now before the thousands of speeding automobiles. In any case, it is not our privilege to demand what we would like, but rather our endeavour to discover what is to be. Certainly the aviator will not forego the opportunity of traversing through space in what, by a sort of unconscious anticipation, has long been termed an "air line," especially as there appears to be no possible way of preventing him from passing over anything which may be beneath.

In considering this phase of the subject it is well to avoid the error of dividing men into classes which, in fact, have no clearly defined limits. There are not to be two groups of individuals, one tied to the surface of the earth and the other having the freedom of the space above, but in the course of time most men will belong to both classes. The analogy of this will be seen in the relation of the farmer to the automobile. The objections of the man in the field and on the country road to the motor which came speeding past him from the city were both violent and unreasonable at first, and any attempts to control the relation by legislation or to modify it by suasion or argument were equally futile. As soon, however, as the development of the art was sufficiently advanced to enable the farmer to become also an owner and operator of an automobile, the antagonism faded away. The new conditions worked their own remedy, but in so doing the old order of things was changed, and this without conscious effort on either part, and with but little perception of the result until it had been effected.

If, then, there is to be added to the scope of man's activities the domain of an entirely new field, one which has not yet been appropriated, and which offers far wider opportunities for expansion and change than those placed before Europe by the discovery of America, we are justified in maintaining that we are on the verge of a transformation in nearly every element of human existence.

More than fifty years ago Lord Macaulay, describing the state of England in 1685, said:

"Of all inventions, the alphabet and printing press alone excepted, those inventions which abridge distance have done most for the civilization of our species. Every improvement of the means of locomotion benefits mankind morally and intellectually, as well as materially, and not only facilitates the interchange of the various productions of Nature and art, but tends to remove national and provincial antipathies, and to bind together all the great branches of the human family."

The truth of this observation has been amply demonstrated by the results of the extension of transport facilities by railway and by steamship since Macaulay passed away. There is every reason to believe that the same results will follow in still greater measure by the opening of the great highway of the air. Many restrictions, which have been accepted solely because they could not be avoided, will doubtless pass away, not as the result of violence, but in consequence of the changed conditions. The conduct of business and commerce cannot remain unaffected; the relations of nations must necessarily become closer and more thoroughly interrelated; warfare, if not wholly eliminated, must be profoundly changed, perhaps more so than at any time since the introduction of gunpowder made the peasant the superior of the armoured knight; while the entire arrangement of buildings and cities, as well as the habits of conduct of life among their occupants, will be transformed.

It will be the object of succeeding articles to examine at length some of these elements in the great transformation, and it is only necessary here again to emphasize the fact that these tremendous changes are as inevitably coming as were those which followed the advent of the steam engine, the steamboat, the steam railway and the automobile. They cannot be materially checked, but it is possible that they may be guided. Mrs. Partington tried to sweep back the rising tide of the Atlantic Ocean, but her energy was wasted. Far better to perceive that it *is* a rising tide, and, taking it at the flood, be carried with it on to fortune.

In the succeeding portions of this discussion there will be considered the modifications which the freedom of the air will create in several important departments of life and work.

In commercial transactions, the ability to transport merchandise, even to a limited degree, directly from shipper to consumer, independently of restricted trade routes and freed from the exactions of rehandling and middlemen, appears to be weighty with consequences. Some of these may clearly be foreseen, others conjectured, others still must soon reveal themselves.

In warfare, the opportunity for the evasion of the enemy's lines must extend enormously the field of operations. If warfare is to continue at all, it must be largely transferred to the air, and, in any case, open up the exposure to danger of the legislators and others by whose initiative hostilities are undertaken. More probably the opening of the freedom of the air will complicate the social, financial and commercial interrelations of civilized nations to such an extent that all possibilities of war in the old sense of the term will disappear and the function of armed forces be limited to the policing of the territories of such peoples as are not yet sufficiently advanced in civilization to be depended upon to maintain order by themselves.

In the conduct of government the limitations upon arbitrary interference with commerce, personal movements and individual initiative must exert profound modifications. With entire freedom of movement above the surface of the earth, it seems probable that corresponding freedom in all international relations must follow. Boundaries will no longer be determined by rivers, mountain ranges, or other surface details, and, in any case, they will lose most of their significance.

The maps already prepared for the use of aviators in Germany, France and portions of the United States show distinctly the minor importance of elements which, until now, have controlled the conditions of movement.

In the conduct of daily life some of the modifications may be foreseen by their analogy to those already effected by the introduction of the automobile. Other changes, notably those which may be expected in the architecture of cities, will demand attention, while many of the problems of municipal congestion may find unexpected solutions.

These, and other elements of the great transformation, will be taken up at length in the succeeding chapters.

(To be continued.)

# ENGINEERING METHODS IN GERMANY AND AMERICA

## A COMPARATIVE STUDY OF AMERICAN AND GERMAN WORKSHOPS

By **William H. Dooley**

It is generally acknowledged that the true way to advance industrial development is to adopt the best methods wherever they may be found. This can best be done by a comparative study of the actual processes of competing communities, provided it is done with an open mind and clear vision. Mr. Dooley has examined some of the establishments on the Continent, and in the present paper he discusses the methods of work in the engineering works of Germany, in the light of an educator who is familiar with the progress of the United States. This study is of especial interest because of the bearing which it has upon technical education, and hence it is of value, not only to American manufacturers, but also to British engineers, who are meeting Germany in competition in other parts of the world to even a greater extent than is true of American manufacturers.—The Editor.

VERY few people realize the difference in organization, and, consequently, efficiency, between Continental and American engineering and metal industries. The very first thing that impresses one as he passes through these industries in Europe is the lack of the thousand-and-one devices to save manual labour that we are accustomed to see in American shops. There is also a lack of division of labour in the metal and engineering factories or plants. One can readily see that they attempt to make all kinds of tools under one roof. Compare this with the establishments in the United States, where the industry is so highly specialized that each factory makes only a few lines of tools, and, in a great many cases, only one type of machine! As a result of these differences in organization the majority of American manufacturers can undersell in European territory the native tool manufacturers, and this despite the lower wages paid to the workmen. To illustrate. The American machine tool houses which are engaged in making boring mills only may be expected not only to turn out a highly specialized tool, but to offer various sizes of this tool in a highly perfected form. Such establishments can hope to undersell every day a European firm which occasionally makes, and then to order, a tool of the same type. This fact is recognized all over Europe. The advantage of the American over the foreigner lies in superior shop organization and in superior technical knowledge.

The question may be asked: "Why does not the Continental manufacturer copy the American shop organization?" This is impracticable, because these methods of organization are distinctly American, and are due to the tendency to abandon the slow hand processes. On the other hand, the tendency on the Continent is to cling to the old hand processes and to disregard the machine processes. Moreover, there has been developed among the metal workers and labouring classes in the United States a mobility such as is unknown elsewhere in the world. In this way ideas and methods have been carried from shop to shop.

Another advantage which has contributed to the rapid development of American methods of manufacture is the comparative freedom from inherited and over-conservative ideas. The United States has entered upon its industrial development (especially the metal trades) unfettered by the old order of things, and with a tendency on the part of the people to seek the best and quickest way to accomplish and manufacture every piece of machinery.

In all the Continental countries or communities where there are metal works the transition from the household or small establishment to the plant or factory was hampered by guilds, and by elaborate national and local restrictions, and by the reluctance with which a people accustomed to generations of fixed methods of work, in which they acquired a large degree of skill, abandon these methods for new ones.

On the other hand, the European manufacturer has the advantage of having the disposition and government on his side. This is a very important point at this period of the world's history, because competition, which naturally exists in a form at least equally acute between the manufacturers of different countries, is liable to be seriously handicapped in the industrial race by want of complete knowledge of the circumstances which either hinder or assist their rivals. Hence a very prominent place must be given to the aptitudes, dispositions and habitual practices of workmen. The European manufacturer is not troubled so much by ignorant labour leaders insisting on that which cannot be granted without serious injury to the business in which they are engaged. The apprenticeship system, in a form, is in vogue, because the manufacturers have more faith in their workers than is the case in America.

Of all the European countries Germany is the nearest rival to the United States. The average American does not realize the gain made by this country. German manufacturers are putting more engineering thought into their designs than at any other time in the history of tool construction. The mechanical skill still holds in favour of the Americans, and will probably remain to their credit in the case of those American firms which are paying close attention to the drawing rooms. Every tool that is imported into Germany is subject to scrutiny, and if engineering skill, backed by careful mathematical deductions, can make an improvement, the German will be the first to discover the fact. Within a short time a new machine will be on the market with some improvements.

The great industrial section of Germany lies along the Rhine, and particularly the iron and steel works are carried on principally in Düsseldorf, Essen, Duisburg, Oberhausen and Ruhrort. The modern industrial evolution of the Rhine district in iron and steel manufactures which have attained such a remarkable development is probably due, in the first instance, to the coal mines of the province and of Westphalia, which adjoins it on the eastern side, and, in the second, to the great waterway of the Rhine and an excellent system of railroads.

In Düsseldorf the iron and steel factories are on the outskirts of the city. The factories (iron and steel) are equipped with foundries and employ a great many men. Messrs. Haniel & Lueg employ 2,000 men and make all kinds of engines and machinery. Heavy machine tools, hydraulic presses and steel ingots are sent to Glasgow and Sheffield; also, crankshafts for electrical machinery in large quantities are sent to Manchester. The working men live in flats, and not in cottages.

To illustrate how slowly factory processes are overtaking the work of the home, the city of Solingen (the cutlery centre) will give the best example.

### SOLINGEN—THE CUTLERY CENTRE

Solingen is a busy, brisk and cheerful country town of 46,000. The people are all engaged in the cutlery trade—about 29,000 are employed. They make knives and forks, scissors and swords. The art is believed to have been brought from Damascus by Graf von Berg on his return trip from the Crusades, but an alternative theory traces it to importation from Styria. However, this may be, Solingen workmen early acquired a wide reputation and sometimes keep their skill far afield. One of the names found on old Toledo blades is German, and is still borne by cutler families in the place. The art was jealously guarded by the old guilds—the smiths, temperers, grinders and finishers—who strictly limited the apprentices and the output. Every master had to have a trademark, which was registered by the local authority, nailed up on a church door, and had a legal validity. The famous sign of the Twins dated from 1731, when it was registered by Peter Henckels; it has been borne by the same firm ever since. Their factory is the largest in Solingen, but out of 2,000 workmen only 800 are employed in the works; the remaining 1,200 work at home. This is the rule. The great bulk of the industry is carried on at home, as in old times, on the "chamber system." It is encouraged by the local authority, which provides the men with gas and electric power in lieu of the old water-wheels. It has thus been preserved and developed alongside of the factories, which first came in during the last century and helped to revive the trade which had come to grief during the French occupation.

In 1898 the Government factory department of Düsseldorf issued a special order in consequence of the prevalence of phthisis among the grinders. In the ten years 1895-1905, 72.5 per cent. of the deaths among knife grinders in the Solingen district was due to phthisis, against 35.3 per cent. for the rest of the population over fourteen years of age, and an official medical examination showed that, out of 1,200 grinders, only 85 were over forty-five years old.

One is greatly surprised that the Solingen figures are no higher. According to the figures, the place is fairly healthy, in spite of the occupations.

As I said before, the departmental authority issued a special order relating to the installation of grinding shops and the removal of dust. In the Henckels Works the arrangements are admirable. Great cleanliness is observed in the smallest details, light and ventilation are ample, extracting fans carry off the dust more efficiently than I have ever seen it done anywhere else, and everything tending to raise dust is carefully eliminated as far as possible; the drying straps and wheels are lodged in a gallery or passage between two shops, and, therefore, outside the room; the stones and emery wheels are protected by special and ingenious hoods. I believe that this is a model factory, and cannot fairly be taken as an average sample. The average American or Englishman has not a very high opinion of German cutlery, and it would surprise one if he only saw some of the excellent quality of cutlery turned out by the German manufacturers.

Cheap and inferior cutlery is turned out at Solingen, and not infrequently with the name Sheffield stamped on it; but they also produce goods of first-rate quality, and are able to compete with Sheffield on their merits. That they turn out very beautiful goods cannot be denied—exquisite specimens of damascened, inlaid, and other fancy work. The superior Solingen cutlery is not cheap; the material is the best Swedish steel, the same that Sheffield uses. An extraordinary thing about the cutlery trade is the almost incredible variety of knives made. At the Suffolk works in Sheffield, for instance, they have 10,000 different patterns on the books, and will be actually making 3,000 to order at the same time. I found the same thing at Solingen; Henckels have 9,000 patterns for Germany alone. Every trade, every country, and even every district has its own knives. New patterns are continually coming out; the Suffolk works have averaged ten new patterns a week for two years. This is a trade which will not be standardized, and that is one reason why America has hitherto failed to compete. Let the fact be noted, to the credit of European alertness and attention to the needs of the market.

The cutlers of Solingen are highly organized in all branches of the trade, though one does not find them down on the lists of any of the large trade federations. The employers also are organized, and there is a joint machinery for settling disputes and prices similar to the trade workers in England.

Boys are usually taken as apprentices; it is looked after by unions, who limit the number. Very few girls are employed. The appearance of the factory has set up the usual house difficulty, which has been met by the building societies. They borrow money from the Landesbank of the province, and the town guarantees 3 per cent. interest. The houses built are of two kinds: (1) Small houses for minor officials, (2) larger ones, containing four to six families of workmen. The average weekly cost is about $0.36 a room. Many of the work people in the district own their houses, and it is the custom of the place for them to keep a goat—the "poor man's cow."

Essen does not represent the most common type of industrial community; it is simply a one-man town, similar to cities in our own country. It might be of interest for us to study the development of Essen and see how it compares with similar American cities. In 1811, when the first crucible furnace for casting steel was set up by a poor, hard-working young man, Frederick Krupp, the total population of Essen was under 4,000. In 1891 it was 183,500, out of which the Krupp contingent numbered about 84,000. Now, this, and a great deal more, is essentially the work of one man, and it is unparalleled in the history of industry. The corporation now owns iron and coal mines and over 4,000 houses.

NUMBER OF EMPLOYEES IN KRUPP WORKS

| | |
|---|---|
| Steel works at Essen and proving grounds. | 33,917 |
| Gruson works at Buckau................. | 3,848 |
| Shipbuilding at Kiel ..................... | 3,746 |
| Coal mines ............................. | 9,896 |
| Blast furnaces, iron ore mines............ | 11,784 |
| | 63,191 |

Apart from Krupp's, the industries are not extensive. The products from Krupp's are very varied. Compare this with the highly specialized condition of the industries in this country. The Krupp's fame is chiefly associated with war materials; but all kinds of finished and unfinished materials for railroads, engines, tools, mills and other industrial appliances are turned out in large and small quantities.

The shops have been built at very different dates, and vary accordingly; but, as a whole, they possess in a marked degree that order and cleanliness which are the most distinguishing features of German factories. This extends to the foundries, where one usually finds dust, smoke and confusion.

A specialty here is the casting of very large ingots of crucible steel. It is a remarkable sight and an object lesson in German methods. Ingots of 85 tons are cast—a feat which is not attempted in any other place. The steel is melted in small crucibles, which are carried by hand, and, therefore, contain no more than two men can lift. Scores of such crucibles go to the making of an ingot of considerable size, and they occupy many furnaces, which are ranged on both sides of the foundry, with the ingot mould in the centre. At the signal the furnaces are opened and the crucibles drawn out and seized by a small army of workmen, who run them down to the mould and pour them in. It is clear that, to do the thing on a large scale, perfect method in preparation and order in execution are necessary. The manœuvre is carried out with military precision and promptness. In a moment the place is aglow with the white heat of the furnace, the figures run from all sides and come staggering down in pairs with the pots full of liquid steel. It is a scene of intense activity, but without confusion. One after another the glowing pots are emptied; the molten lead runs like thick soup and plumps into the mould with a bright sputter. In a few minutes it is all over; the furnaces close again, the used crucibles are thrown aside, and already the cast mass begins to congeal and change color, while presently it dulls to yellow, and the tint deepens as you watch. The steel so made is the purest known, close-grained, homogeneous and uniform throughout. This is not done in the United States, where the impatience of hand processes, which is characteristic, and has led to such remarkable developments of automatic machinery, has its weak side. The most recently built workshops at Kruppe are quite up-to-date in their construction—light, spacious and airy; but they are no way superior to the ones in Sheffield, England.

The most striking feature of German iron and steel factories is their clean, orderly and well-kept condition. These qualities seem to be universal, and they extend to the dirtiest and most untidy departments. The German foundries were a revelation to me. They are as clean and well kept and almost as light as any other shop. The remarkable order maintained is systematic, and, in a large measure, intended to promote the prevention of accident. In the accident-prevention rules of the Rhine-Westphalian Engineering and Small Iron Industries Association I find in the first paragraph that "The gangway in all workshops must be broad enough to exclude, as far as possible, injury to persons using them by machinery or transmission parts in motion. They must be kept in good condition, and must not be blocked by the heaping of material or the transportation of articles."

Compare this with most American engineering shops. There is no room. The different parts of the American shops are congested, and manufactured or half manufactured articles are lying promiscuously about, blocking the gangway. The entire freedom from such disorder in German shops and workrooms undoubtedly conduces to efficiency, as well as to safety, and it is secured chiefly through the habits of order inculcated into all alike—workmen, managers and owners—by the military discipline they have all likewise undergone. Fencing of machinery, however, is less complete and costly than that which is required in most factory districts in England and America.

With regard to the installation of machinery and workshop appliances, the German establishments are, generally speaking, quite up to the mark. They make use of electric power, automatic tools and similar modern devices, and meet with no opposition on the part of the work people. Machinery and tools are procured from any part of the Continent or any country, without regard to any consideration but suitability; but Germany, year by year, is becoming more self-sufficing in this respect. Their small tools are as good as the American, their heavy ones as the English.

Outside the rooms the workshops are well provided with sanitary washing and dressing accommodations. The workmen are more cleanly and careful in their habits than the English; they generally keep a working suit of clothes and change before and after work. Consequently, lockers are provided. Baths are common, particularly shower baths, with hot and cold water, and in summer they are much used. The practice of providing comforts and conveniences for the employees is more common in Germany than in America or England.

The employees in the German iron and steel factories are good, steady, regular and trustworthy, but not as quick as the Americans. They do what they are told to do, and do it well. German mechanics are often seen working on an engineering order from England, and they use the original drawing with the English measures. Could an American mechanic do the same? The German mechanics are not in the least inventive; they never make suggestions, nor is there any system of encouraging them to do so, but they keep the rules and do not shirk. This is one of the principal reasons why the German industry is so strong.

Roughly speaking, the working hours in the metal and engineering works are ten hours a day. The following time schedules, taken from various representative machinery works, will show exactly the length and distribution of the day's work:

HOURS IN ENGINEERING WORKS AT DÜSSELDORF

| | |
|---|---|
| Begin | 6.30 A. M. |
| Breakfast | 8.15 to 8.30 A. M. |
| Dinner | 12 to 1.30 P. M. |
| Tea | 4.15 to 4.30 P. M. |
| Close | 6.30 P. M. |

Total, 12 hours, minus 2 hours for meals, equals 10 hours. Week, 60 hours.

HOURS IN MACHINERY WORKS AT DÜSSELDORF

| | |
|---|---|
| Begin | 7 A. M. |
| Dinner | 12 to 1.30 P. M. |
| Close | 6.30 P. M. |

Total, 11½ hours, minus 1½ hours for meals, equals 10 hours. Week, 60 hours.

HOURS IN CUTLERY WORKS AT SOLINGEN

| | |
|---|---|
| Begin | 7 A. M. |
| Breakfast | 9 to 9.15 A. M. |
| Youthful workers | 9 to 9.30 A. M. |
| Dinner | 12 to 1.30 P. M. |
| Tea | 4 to 4.15 P. M. |
| Youthful workers | 4 to 4.30 P. M. |
| Close | 7 P. M. |

Total, 12 hours, minus 2 hours for meals, equals 10 hours. Week, 60 hours for men, 58½ hours for women. (Law forbids the employment of women after 5.20 P. M. on Saturdays and on the eve of the holidays.)

HOURS IN ENGINEERING WORKS AT CHEMNITZ

| | |
|---|---|
| Begin | 6 A. M. (winter, 7 A. M.) |
| Breakfast | 8 to 8.30 A. M. |
| Dinner | 12 to 1 P. M. |
| Tea | 4 to 4.15 P. M. |
| Close | 6 P. M. (winter, 7 P. M.) |

Total, 12 hours, minus 1¾ hours for meals, equals 10½ hours. Week, 61½ hours.

HOURS IN STEEL WORKS AT ESSEN (KRUPP)

| | |
|---|---|
| Begin | 6 A. M. |
| Breakfast | 8 to 8.15 A. M. |
| Dinner | 12 to 1.30 P. M. |
| Tea | 4 to 4.15 P. M. |
| Close | 6 P. M. |

Total, 12 hours, minus 2 hours for meals, equals 10 hours. Week, 60 hours.

The great difference between England, the United States and Germany is that Germany averages about one day more than England and the United States. The difference is due to the half holiday on Saturday and difference of meal hours in this country and England. The deliberateness and respect for hours are as characteristic of Germany as indifference to them and living of the United States.

Wages are but little less in the manufacturing (Rhineland) section of Germany than in Germany. In engineering workshops in Prussia, fitters—called engineers in England—earn $8.76; men doing the same work in England are getting $9.25 a week, while in the United States they average $16.50.

As to the cost of living, it might be of interest to know that there is little, if any, difference between rents in Germany and in England. As regards food, it must be borne in mind that the German workman takes much more of certain food commodities than the Englishman, chiefly potatoes and milk, which are cheaper in Germany than England. It might be said that an English workman, migrating to Germany, and maintaining, as far as possible, his own standards of living, would find the cost of food and fuel raised by about one-fifth, while the German workman who migrated to England, but retained his own habits of living, would find his expenditure on the same items reduced by less than one-half that amount.

The writer has already pointed out that the American manufacturer of machine tools excels the European manufacturer in shop efficiency and superior technical knowledge. But the European shop manufacturers are learning wonderfully well how to get the maximum capacity of work out of tools. Of course, it takes time, and one can often see two men on a gear cutter where the American designer of tools never contemplated that more than one man should be employed. On the whole, they do not yet understand, in the great majority of German workshops, how to operate the greatest number of tools with the least number of men. This calls for the highest degrees of intelligence and skill, such as are found to-day in the most enhanced form in the best American shops. But this is something that can be copied, and is being copied, by European manufacturers, to the extent that they have organized within the last two years Work Leagues, whose aim is to reform the old-fashioned state of manufacturing and production in Europe, so as to bring it on a plane of efficiency equal to the industries of this country. These associations are meeting with a general and lively interest and sympathy in all circles, particularly in Germany, where it promises to fill a national want—the increase of Germany's export trade.

It is clear that if the Americans propose to keep ahead in shop efficiency and in ability to run a shop with the least possible number of men, they must look to the training of the workmen from boyhood up. This can no longer be done by the crude methods of the present specialized machine shops, but by this experience, supplemented by industrial or technical education.

European countries are far ahead of the United States in this training. The old-fashioned machine shop of a century ago no longer exists, with the master workers and few apprentices. The masters took the boys and were bound to teach them every part of the machine trade during a certain number of years. This was an excellent method of training boys, for it provided both the theoretical and practical experience. But later in the last century a great change took place in our industrial field, due to a great era in prosperity. Competition became keen, and, as a result of the Civil War, there was a scarcity of mechanics. Masters had to meet this competition, and found that it was necessary to have each man specialize on some particular machine. There was no longer any time to teach apprentices the complete trade. Each manufacturer began to make a certain line of work, and the men were trained to be specialists on certain machines. On the other hand, the industry became so complex that the young man found that he could no longer learn its fundamentals. With this great change in industrial organization in the United States the public failed to provide suitable conditions to meet the new educational needs of the apprentice in the machine and engineering trades.

European countries, particularly Germany, saw, with the changes in industrial life, that the shop was not providing the proper training for the young apprentice. The government provided schools for the apprentices to attend Sunday mornings and certain periods of the week. Thus we see the first stages of technical education in the metal trades. These schools are called Continuation Schools. The individual subjects of instruction which are in the closest possible connection with the requirements of the engineering and machinists' trade are as follows: Trade calculations, with bookkeeping; business correspondence and reading; the study of life and citizenship; mechanical drawing, physics and machinery; materials and shop work. Every apprentice is allowed by his employer to attend this school ten hours a week without loss of pay. It is in these Continuation Schools that those who are to form the rank and file of the metal trades receive their theoretical and basic training.

In addition to these Continuation Schools, the government provides different types of special schools to meet either the young, the old, the mediocre, or exceedingly bright mechanic who desires to advance himself in his trade.

If one desires to become a skilled mechanic in machinery of precision and electricity, the school, as the Berlin School of Trades and Crafts, will provide the proper instruction in special lines of machinery. Then there is a school for working men of the different metal industries, who have completed the courses in the lower industrial schools and desire a preparation for positions between journeyman, machinist and engineer, or draftsman. They have every opportunity to attend these schools, as there are four distinct types of schools preparing for the above positions. They are: The schools of industry (Industrie Schulen), the master workmen's schools (Werkmeister's Schulen), the higher trade schools (Höhere Schulen), and the Technicum.

The school of industry (Industrie Schulen) offers to skilled and ambitious workmen in the metal trades a higher education. It was established for the purpose of preparing the apprentice journeyman to become a master workman. No pupil is admitted before the age of 16, and he is expected to have had two or three years of practical experience in the machinist's trade. The studies are chiefly in the direct line of the machinist's trade, and the course required is from one to one and a half and even two years. The pupil must devote his whole time to the course.

The master workman's schools have long been very popular in Germany among the metal workers, and are intended mainly for men of a much larger shop experience than the minimum limit, who wish to broaden their trade horizon. They take in the older men in the metal trades, those who have been long out of school and who never expect to become thorough book students, but whose strength lies in their shop skill. These men have only moderate aspirations for advancement; they may be ambitious to own little machine shops of their own, but do not expect to rise high in the scale of superintendent or become the heads of great industries. Such men have usually receptive minds and possess good judgment. They expect to obtain in the schools, through direct practical teaching, the necessary theory to enable them to carry out the higher demands of the trade. Such schools have been, and must of necessity remain to a great extent, evening schools, for they have existed to give the man who, by his superior abilities, has come to the front in the machine shop a chance to prepare himself for higher duties. It takes years, however, under ordinary conditions, for this man to impress his peculiar fitness for a foreman's duties on his superintendent or employer, and he has attained early middle age at least before recognition comes to him in the form of an offer. In all probability he then has a family dependent upon him, and under present conditions he cannot give up his day's work to attend a day school.

The higher trade school (Höhere Schulen) for machinists and metal workers are, in some respects, the most advanced type of these middle technical schools, since they demand for entrance both a fair degree of advancement in elementary mathematics and physical science and well developed skill as a workman. These schools are expected to develop ambitious young men who may expect to attain higher positions in larger machine shops and metal factories where practical men are needed; some of them may even enter the technical universities to prepare themselves for the highest engineering positions. In looking over the catalogue of this school, a great many of the students are not following their fathers' calling.

The technicums have, in most cases, a lower age limit than the other schools—no pupil under 15 years of age being admitted—and require for admission a year or two of high-school study and only a year of practical experience in the machine shop. Thus it becomes essentially a low grade school of practical technology.

One cannot help being impressed with the systematic way in which Germany is educating all the people. We believe in educating only those preparing for the professions—some per cent. of the working population. Here is an example where all the above schools are intended to fulfill the same general object; but that differences in detail arises from different ideas as to the manner in which results may be attained, as well as the different classes of working people to be suitably provided for.

The importance of these schools cannot be too highly estimated. They are the main pillar by which the German metal and engineering industries have reached their high standard, and will later, when the American organization has become part of the German shop, be superior to the American standard, unless the United States immediately organizes similar schools in her communities.

There is a danger in most American technical schools, due to the fact that they do lay great stress on the workshop. The students are apt to learn to become extravagant with the material provided for practice, and fail to learn the economy of practical shop life. This is guarded against in the German schools by doing work on a commercial scale. The products of the shop are nearly all sold, and, in many cases, material is supplied by the metal trades in a raw state (rough castings from the foundry for the machine shop) or partially manufactured state, to be worked up in the various departments. The actual conditions of the machine shop, foundry, etc., are thus observed in the schools to a greater degree as possible. In this way the schools keep in touch with the industries.

# THE APPLICATION OF HEYLAND'S VECTOR DIAGRAM FOR TESTING INDUCTION MOTORS

By J. W. Rogers

ALTHOUGH it is a well-known fact that the circle diagram offers a valuable and convenient method of determining the various characteristics of an induction motor under different operating conditions, information dealing with the results of actual tests worked up with the aid of Heyland's diagram is not often met with, and for this reason the writer thinks a practical example of its use will prove of interest, being generally considered the most accurate method of determining the complete performance of an induction motor.

Before dealing with the application of the circle diagram it may be well to mention a few facts connected with the theory of the induction motor, and also the graphical construction by which these facts are represented, from which the construction of the diagram as used in practice has been developed. As is well known, graphical construction represents the magnitude and phase relation of the magnetic fluxes in an induction motor, which consist of (1) working flux, (2) stator leakage flux, (3) rotor leakage flux; and these may be considered separately, as follows:

The total working flux is the resultant of the stator flux set up by the primary current and the flux caused by the induced current set up in the rotor winding, that part of the primary current which gives rise to this working flux being known as the magnetizing current, which is the resultant of the primary and secondary currents.

The total working flux is due to the resultant of the vector difference of the impressed voltage per phase and the C. R. drop in the stator winding, and one component of this flux corresponds to the reactance volts in the primary and is only interlinked with that winding.

The stator leakage flux is the other component of the primary flux and represents the difference between the total working flux and that due to the primary reactance voltage. It represents that part of the total flux which does not enter the stator, but passes from tooth to tooth; and, although it does not affect the rotor conductors, it exists as a self-induction in the stator windings. The secondary, or rotor leakage flux, is that part of the flux set up in the rotor core which does not enter the stator. It generates a back E. M. F. in the rotor windings, and tends to demagnetize the stator, causing an increase in the stator current. When a motor is running, the stator and rotor leakage increases with the load; but when stationary with the rotor on open circuit there is no current in the rotor winding, and, consequently, no rotor or leakage flux, in which case the primary current will only give rise to a stator flux and leakage.

The magnitude and phase relation of these fluxes may be graphically represented by the diagram in Fig. 1, which, however, does not take into account the primary resistance and secondary leakage. Let $O\ V$ represent the voltage applied to the primary winding; then $O\ V_1$ equals the back E. M. F. developed in the primary, which will be equal in magnitude, but in direct opposition, as regards its phase. The total primary

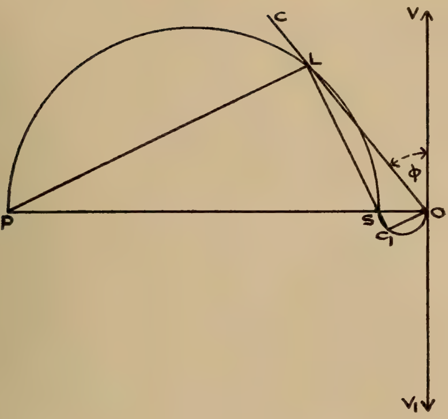


FIG. 1.—FLUX DIAGRAM

flux which produces this back E. M. F. is represented by $O P$. 90 degrees in advance of $O V$.

Let $O C$ be the primary current lagging behind the applied voltage by the angle $\phi$. As the leakage flux is produced by the primary current it will be in phase with and proportional to $O C$, and may be represented by $O L$. The secondary flux is the vector difference of the primary and leakage fluxes, and is represented by $P L$. As an E. M. F. always lags 90 degrees behind the flux producing it, the induced E. M. F. in the secondary is given by $L. S$, which is at right angles to $L P$, and $L S$ also represents the phase of the secondary current, as the magnetic leakage in the secondary is assumed to be negligible. The magnetizing current taken by the motor is the vector difference of the primary and secondary currents and is in phase with the secondary flux; it may, therefore, be represented by $O C_1$ drawn parallel to $L P$. Upon the lines $S P$ and $O S$, as bases, two semicircles may be drawn. The large one, $P L S$, will represent the conditions existing when a motor is so overloaded that its rotor is held stationary, and $S C_1 O$ will represent the conditions when the motor is running light.

When a motor is running light the leakage flux may be considered negligible, in which case the secondary flux will be equal to the primary flux—that is to say, the points $L$ and $C_1$ will fall on $S$, and the primary current will then be $O S$. On the other hand, when a motor has the normal voltage applied to the primary winding and its rotor is held stationary, the secondary flux will entirely disappear, and the leakage flux will then have the same value as the primary flux— that is to say, the point $L$ will move round the semicircle to point $P$, the primary current being in this case represented by $O P$. It follows, therefore, that the diameter $O P$ represents the primary current taken by a motor having a resistanceless secondary which is held stationary, and is determined by the reactance of the primary and secondary windings. The terminal voltage under these conditions would be the sum of the reactance volts in both windings.

From the above remarks it follows that the construction of the circle diagram requires a knowledge of the magnetizing current taken by a motor, and also the short-circuit current, due to its inductance or reactance when the rotor is held stationary.

As is well known, the primary current taken by an induction motor is made up of two components—viz., an "energy" and an "inductive" component.

The "energy" component represents that part of the primary current which is in phase with the terminal voltage; it gives true energy, and varies with the output of the motor. The "inductive" component represents the wattless or idle part of the primary current, which lags 90 degrees behind the terminal voltage. This inductive component depends upon the magnetizing current taken by a motor, and also upon its magnetic leakage. It performs no useful work, and is constant at all loads, but gives rise to a lagging current, and, consequently, affects the power factor. Although the current input to a motor running light is generally taken to represent its magnetizing current, its true value is slightly less than the light-running current, as a certain part of the latter is spent in overcoming hysteresis and eddy-current losses. If a motor is run light and readings of watts and input current are taken at normal voltage, the magnetizing current may be calculated in the following manner:

Apparent input =

$$= \sqrt{\text{energy component}^2 + \text{inductive component}^2}.$$

∴ Inductive component =

$$= \sqrt{\text{Apparent input}^2 - \text{energy component}^2};$$

that is to say, the true magnetizing current =

$$= \sqrt{\text{total current}^2 - \text{energy current}^2},$$

where energy current = real watts ÷ terminal volts.

As the difference between the "no-load" and the magnetizing current is generally not more than 2 per cent., it is the custom to take the primary current input to the motor running light as representing the magnetizing current. The magnetizing current will then be obtained by running the motor light at its normal voltage and frequency and taking readings of current and watts from which the no-load power factor may be calculated.

The short-circuit test is made by locking the rotor and taking readings of primary current, watts and volts, and when the capacity of the motor is not too great to permit the current to be conveniently measured and the motor is not liable to be dangerously overheated, this test should be made at the normal voltage; but in cases where it is necessary to use a low voltage the value of the current and watts at the normal volts may be calculated from the fact that the current is directly proportional to, and the watts vary as the square of, the voltage. A knowledge of the primary resistance is also necessary, so that the voltage drop in the primary winding may be calculated.

The circle diagram constructed from data given by these tests will assume the form of that shown in Fig. 2, which, although developed from the diagram in Fig. 1, differs

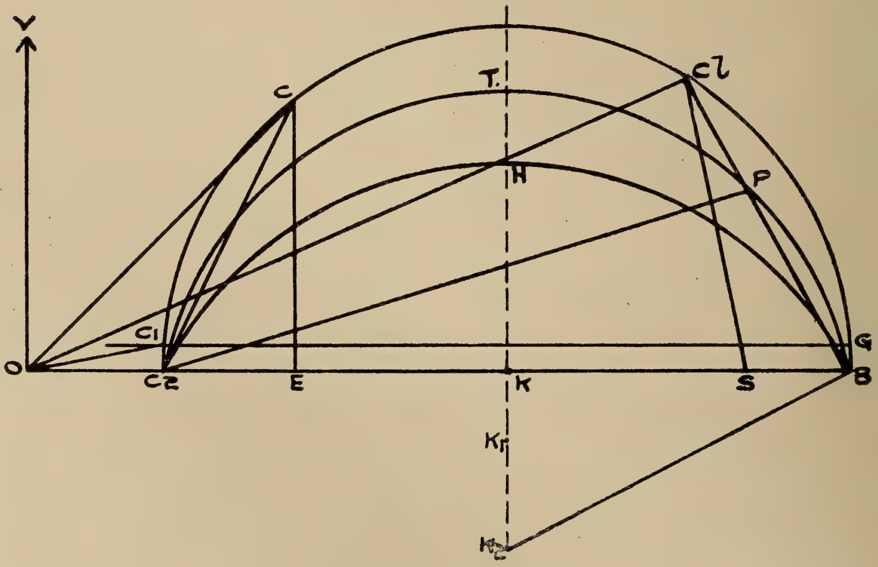


FIG. 2.—CORRECTED CIRCLE DIAGRAM

from it in having been corrected to allow for all losses taking place in a motor.

Referring to Fig. 2, $O\ V$ is the terminal voltage and $O\ C_1$ the primary no-load current, consisting of a magnetizing component, $O\ C_2$, and and energy component, $C_1\ C_2$. The short-circuit or locked current is represented by $O.\ C\ l$, and the semicircle described from centre $K$ on base line $O\ B$ must pass through the points $C_1$ and $C\ l$. This represents the circle of input, and all lines drawn from the point $O$ to the arc of this semicircle will represent the primary input current, which may have any value between the no-load current $C_1$ and the locked current $C\ l$. If we consider one particular value of the primary current $O\ C$, this consists of the magnetizing component $O\ C_2$, an energy current $C\ E$, and a leakage component $E\ C_2$. There is also another component, $C\ \ C_2$, which serves to balance the secondary current. The ordinate $C\ E$ represents the real horse-power developed by the motor for the primary current $O\ C$, and if it were not for the losses occurring in the motor the ordinate $C\ E$ would also represent the torque and brake-horse-power. As is well known, the losses taking place in a motor consist of (1) magnetizing losses in the primary and secondary, (2) primary copper loss, (3) loss due to friction and windage, (4) loss due to slip, which includes the secondary copper loss. The no-load loss includes the first three quantities, which remain practically constant at all loads, with the exception of the primary copper loss, which increases as the square of the primary current. The rotor iron loss also varies slightly with the load, being proportional to the slip, owing to the fact that an increase in the slip causes an increase in the frequency of the rotor currents. The no-load loss may be represented on the diagram by the line $C_1\ G$ drawn parallel to the base $O\ B$ at a distance above it equal to the ordinate $C_1\ C_2$. The line $C\ l\ B$ is divided into two parts, representing the $C\ R$ drop in the primary and secondary windings, $C\ l\ P$ being the primary drop measured to the same scale as $O\ V$. The semicircle drawn through the points $C_2\ P\ B$ will represent the secondary input or circle of torque, the torque developed being proportional to the ordinates of points lying on this circle, such as point $T$, no load losses being neglected. The circle of output will be less than the circle of torque by an amount corresponding to the ohmic drop in the secondary winding; it will, therefore, be represented by the circle $C_2\ H\ B$, to which the line $C\ l\ B$ is a tangent at point $B$. If a line $C\ l\ S$ be drawn, making an angle $B\ C\ l\ S$ equal to the angle $B\ C_2\ P$, this line will represent 100 per cent. slip to some definite scale, as $C\ l$ is the locked point, and, therefore, corresponds to zero speed. This completes the circle diagram which may be used to determine the values of apparent, real and brake-horse-power, power factor, efficiency and slip corresponding to any particular value of primary current; in fact, the complete performance of a motor may be easily determined, with the exception of its temperature rise.

As the tests giving the data required for the construction of the diagram have already been described, the application of the diagram for determining the performance of a 30 horse-power, 415-volt, three-phase induction motor may serve as an interesting example. This motor had a squirrel-cage rotor and a synchronous speed of 750 R. P. M., and the following figures represent the results of the tests.

*Running Saturation.*—The no-load readings obtained from this test were:

Terminal volts = 415. Primary current = 20.1 total amperes. Real watts = 785.

Apparent watts = 20.1 × 413 = 8,350.

$\therefore$ No-load power factor $= \dfrac{785}{8{,}350} =$ 9.4 per cent.

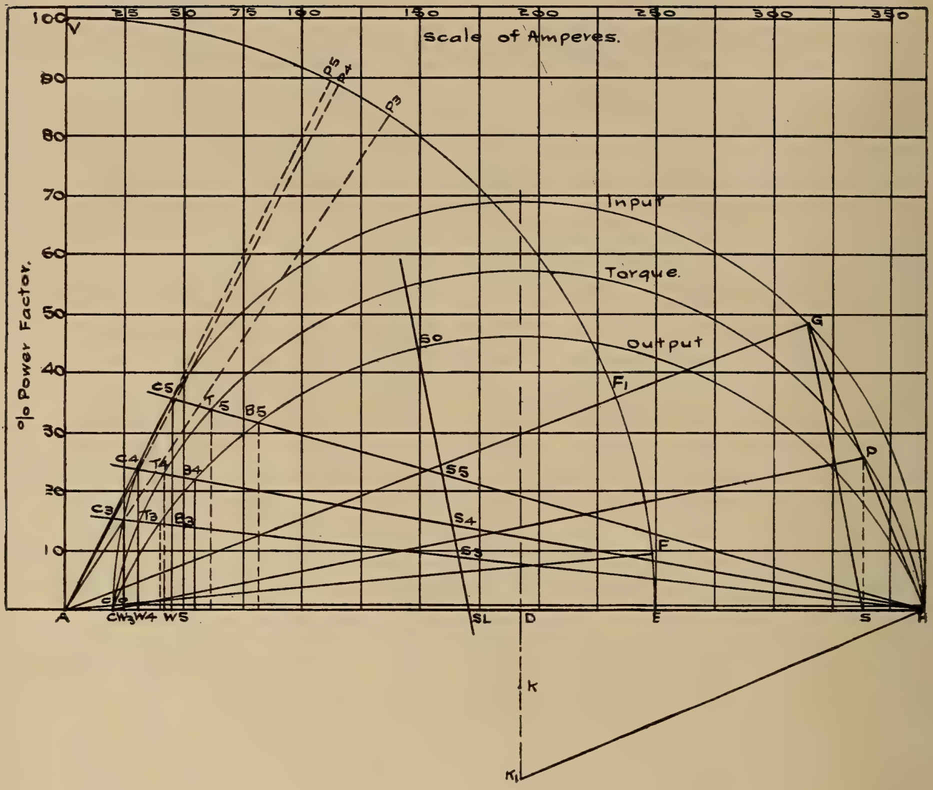


FIG. 3.—APPLICATION OF CIRCLE DIAGRAM

*Locked Saturation.*—The primary current at 415 volts with the rotor locked = 337 total amperes.

Real kilowatts = 50.187 ∴ P. F. =

$$\frac{50.187}{337 \times 415} = 35.9 \text{ per cent.}$$

The stator resistance, after being corrected for standard temperature, had a mean value of $.414^w$ between terminals, and as the total resistance of a three-phase winding is equal to half the resistance between terminals, then primary resistance = $.414 \div 2 = .207^w$.

Having obtained the necessary data, the diagram is constructed in the following manner, reference being made to Fig. 3. From point *A,* at the extremity of the base line *A H,* erect the perpendicular *A V* to represent the direction of the voltage applied to the motor terminals. If *A V* is divided into 100 equal parts, it may be taken to represent the scale of power factor, and the arc *V E,* described with *A* as centre and *A V* as radius, will represent the power factor quadrant.

The "no-load" and locked current vectors, *A C o* and *A G,* are set off to the appended scale at definite angles corresponding to their respective power factors of 9.4 per cent and 35.9 per cent., these being represented on the power factor quadrant by the ordinates of their intersecting points, $F$ and $F_1$. The semicircle described from centre *D* and passing through the points *Co, G* and *H* will then represent the input circle, on the arc of which all vectors representing the primary current will terminate. Next draw the line *G H* and set off the part *G P* to represent the ohmic drop in the primary winding, the length *G P* being calculated in the following manner:

The primary ohmic drop with the rotor locked is $337 \times .207 = 69.75$ volts, and the base line *A H* may be taken to represent the normal terminal voltage to some definite scale, in which case the length *G P* is given by the value of $A\ H \times 69.75 \div 415$. As the scale of *A H* is the same as *A V*, its length will be 146 divisions, so that the length of $G\ P = 146 \times 69.75 \div 415 = 24.5$ divisions. Set off the part $G\ P = 24.5$ and join *C P*, then the semicircle described from centre *K* and passing through the points *C. P. H* will represent the circle of torque. The circle of output has for its tangent the line *G H* at point *H*, and its centre $K_1$ will be the point of intersection of a perpendicular to *G H*, with a line passing through the points *D* and *K*.

The construction for the slip consists in setting off an angle, *S G H*, equal to angle *H C P*, then the line *G S* will represent 100 per cent. slip, because *G* is the locked point and corresponds to zero speed. The line *S O. L S* is drawn parallel to *G S* at any convenient distance from it, so that small values of slip may be read off to a fairly large scale, and this completes the construction of the diagram.

To determine the performance of a motor from its circle diagram, first calculate the total current input required to develop its rated horse-power, which is given by

$$\frac{\text{B. H. P.} \times 746}{\text{term volts} \times \text{App. Eff.}}$$

The apparent and not the real efficiency should always be used when calculating the input current, as the former takes into account the power factor, which cannot be neglected when it is required to know the actual power developed by the motor. The full-load apparent efficiency of the motor referred to in this example is 77.7 per cent., so that the input current $= \dfrac{29.2 \times 746}{415 \times {\cdot}777} = 67.5$ total amperes, or 39 amperes per phase.

As the full-load current is generally increased by 50 per cent. to enable the performance on overload to be determined, the maximum value of the input current will be taken as 100 total amperes, the data corresponding to different values of input current being read off the diagram in the following manner: Commencing with the overload point, lay off the current vector *A C* 5, equal to 100 amperes (by scale), on the arc of the input circle and join *H C* 5, cutting the circles of torque and output and also the line of slip in the points *T* 5, *B* 5 and *S* 5, respectively, then the ordinates of these points will give data representing the performance of the motor at the load corresponding to 100 primary amperes (total). The input-current vector consists of a working component, *C* 5. *W* 5, and a wattless component, *A. W* 5, this latter component consisting of a magnetizing component, *A C*, and a leakage component, *C. W* 5. Now the percentage magnetizing current is given by

$$\frac{A\,C}{A\,C\,5} = \frac{20}{100} = 20 \text{ per cent., and}$$

the percentage leakage component =

$$= \frac{C\,W\,5}{A\,C\,5} = \frac{25}{100} = 25 \text{ per cent.}$$

The total iron loss $= 20 + 25 = = 45$ per cent.

$\therefore$ Power factor $= \sqrt{100^2 - 45^2} = = 89.25$ per cent., which corresponds to the value given by the ordinate of the point *P* 5, representing the extremity of the current vector *A C* 5 on the power factor quadrant *V E*.

Ap. H. P. = length of vector $A\,C\,5 \times \times 415 \div 746$
$= 100 \times 415 \div 746$
$= 55{\cdot}7$ H. P.

Real H.P. = ordinate of $C\,5 \times 415 \div 746$

$= 89 \times 415 \div 746$

$= 49.5$ H. P.

B. H. P. = (ordinate of $B\,5$ — ordinate of $C\,O) \times 415 \div 746$

$= 76.5 \times 415 \div 746$

$= 42.6.$

Real Eff. = brake H. P. ÷ real H. P.

$= 42.6 \div 49.5 = 86$ per cent.

App. Eff. = brake H. P. ÷ app. H.P.

$= 42.6 \div 55.7 = 76.5$ per cent.

The torque developed at 1 foot radius is given by

$$\frac{(\text{ordinate of } T\,5 - \text{ordinate of } C\,O) \times 415 \times 7.04}{\text{synchronous speed.}} =$$

$$= \frac{82.4 \times 415 \times 7.04}{750} = 320 \text{ lb.}$$

As regards the slip, the scale for the slip line, $S\,O$, $S\,L$, is given by

$$\left(\frac{\text{Synchronous speed}}{\text{Ordinate of G}} \times \frac{H\,S}{H\,S\,L}\right)$$

As already stated, $G$ represents the locked point corresponding to 100 per cent. slip—i. e., zero speed.

$\therefore$ The total length $G\,S = 750$ R. P. M. If the slip is measured on the power factor scale, then 100 per cent. slip—i. e., the ordinate of $G$—will measure 48 divisions, the value of $\frac{HS}{H\,S\,L}$ being read off the same scale.

The value of the scale of slip will then be $= \left(\frac{750}{48} \times \frac{10.5}{78}\right) = 2.1$—that is to say, each division on the power-factor scale will represent a slip of 2.1 revolutions per minute. The slip in R. P. M. for the ordinate of the point $S\,5$ = ordinate of $S\,5 \times 2.1 = 22.9 \times 2.1 = 48.1$ R. P. M., corresponding to a motor speed of 702 R. P. M.

$\therefore$ Slip $= 48.1 \times 100 \div 750 = 6.4$ per cent.

The torque developed at 1 foot radius is also given by

$$\frac{\text{B. H. P.} \times 5{,}252}{\text{speed}} = \frac{42.6 \times 5{,}252}{702}$$

$= 319$ pounds.

The current vector, $A\,C\,4$, represents the full-load point, and has a value of 67.5 total amperes.

Ap. H. P. $= 67.5 \times 415 \div 746 =$

$= 37.6$ H. P.

Real H.P. = ordinate of $C\,4 \times 415 \div 746$

$= 59.6 \times 415 \div 746$

$= 33.2$ H. P.

B. H. P. = (ordinate of $B\,4$ — ordinate of $C\,O) \times 415 \div 746$

$= 53.2 \times 415 \div 746$

$= 29.6$ H. P.

Real efficiency $= 29.6 \times 100 \div 33.2 = 89.2$ per cent.

Magnetizing current $= 20 \times 100 \div 67.5 = 29.6$ per cent.

Leakage component $= 11 \times 100 \div 67.5 = 16.3$ per cent.

$\therefore$ Total iron loss $= 29.6 + 16.3 = 45.9$ per cent.

and power factor $= \sqrt{100^2 - 45.9^2} = 88.7$ per cent.

$$\text{Torque at 1 foot radius} = \frac{(\text{ordinate of } T\,4 - \text{ordinate of } C\,O) \times 415 \times 7.04}{\text{synchronous speed.}} =$$

$= 55.5 \times 415 \times 7.04 \div 750 = 216$ lb.

The slip = ordinate of $S\,4$ × scale of slip
= 14 × 2.1 = 29.4 R.P.M.

∴ % slip = 29.4 × 100 ÷ 750 = 3.92, which gives a motor speed of 720 R. P. M.

The vector $A\,C\,3$ scales 45 total amperes.

Ap. H. P. = 45 × 415 ÷ 746 =
= 25 H. P.

Real H.P. = ordinate of $A\,C\,3$ ×
× 415 ÷ 746 = 37.5 ×
× 415 ÷ 746
= 20.88 H. P.

B. H. P. = (ordinate of $B\,3$ —
— $C\,O$) × 415 ÷ 746
= 34 × 415 ÷ 746
= 18.9 H. P.

Real Eff. = 18.9 × 100 ÷ 20.88
= 90.5 per cent.

$$\text{Pr. Fac.} = \frac{\text{Real H. P.}}{\text{Ap. H. P.}} = \frac{20.88}{25} \times 100 = 83.5 \text{ per cent.}$$

Torque at
1 ft. Rds. = 35 × 415 × 7.04 ÷ 750
= 136.4 lbs.

Slip = ordinate of $S\,3$ × scale of slip
= 8.4 × 2.1 = 17.65 R. P. M., giving a motor speed of 732 R. P. M.

∴ Slip = 17.65 × 100 ÷ 750 =
= 2.35 per cent.

The starting torque, as read off the diagram, is given by

$$\frac{(\text{ordinate of } P - \text{ordinate of } C\,O) \times 415 + 7.04}{\text{synchronous speed}} =$$

$$= \frac{63 \times 415 \times 7.04}{750} = 245 \text{ lb.}$$

$$\therefore \text{The ratio} = \frac{\text{starting torque}}{\text{full load torque}} = \frac{245}{216} = 1.14$$

the starting torque being low, due to a low rotor resistance. The maximum torque developed is given by

$$\frac{(\text{ordinate of point } D \text{ to circle of torque} - \text{ordinate of } C\,O) \times 415 \times 7.04}{\text{synchronous speed.}} =$$

$$= 141 \times 415 \times 7.04 \div 750 = 549 \text{ lb.}$$

$$\therefore \text{Ratio } \frac{\text{maximum torque}}{\text{full load torque}} = \frac{549}{216} = 2.54.$$

The accuracy of the data obtained from the diagram may be checked by working up the performance curves from the losses in the following manner: The efficiency of an induction motor is given by

$$\frac{\text{Power in watts converted into H. P. at pulley}}{\text{watts input}} =$$

$$= \frac{\text{Watts input} - \left\{ \begin{matrix}\text{stator}\\ \text{copper loss}\end{matrix} + \left( \begin{matrix}\text{no load}\\ \text{stator loss}\end{matrix} - \begin{matrix}\text{no load}\\ \text{stator copper}\\ \text{loss}\end{matrix} \right) \right\} \times 1 - \text{slip}}{\text{watts input}}$$

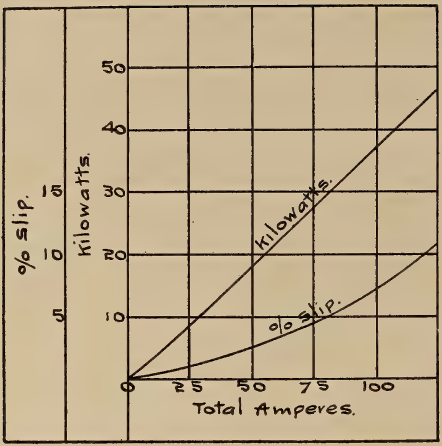


FIG. 4.—POWER CURVES

and by taking any particular value of total amperes on the power curves shown in Fig. 4 and reading off the corresponding values of real kilowatts and percentage slip, the different quantities may be worked out with this formula. Taking 100 total amperes, the corresponding values are 37 real kilowatts, 7 per cent slip, giving a speed of 697 R. P. M. Terminal volts = 415. The stator copper loss = $100^2 \times .207 = 2{,}070$ watts. No-load loss taken from running saturation = 785 watts. No-load current = 20.1 total amperes. ∴ no-load copper loss = $20.1^2 \times .207^w = 83.6$ watts.

Substituting these values in the formula given above, we get

$$\frac{37{,}000-[2{,}070+(785-83.6)]\times 1-.07}{37{,}000}=$$

$$=\frac{(37{,}000-2{,}771)\times .93}{37{,}000}\quad\frac{31{,}890}{37{,}000}=86.25 \text{ per cent. real efficiency.}$$

Real H.P. = 37,000 ÷ 746 = 49.65 H. P.

B. H. P. = real watts — losses ÷ ÷ 746
= 31,890 ÷ 746 = 42.75 H. P.

Ap. H. P. = total amperes × terminal volts ÷ 746
= 100 × 415 ÷ 746
= 55.7.

App. Eff. = 42.75 × 100 ÷ 55.7 = = 76.7 per cent.

Pr. Fac. = 49.65 × 100 ÷ 55.7 = = 89.2 per cent.

$$\text{Torque at 1 ft. Rds.} = \frac{42.75 \times 5{,}250}{697} = 322 \text{ lb.}$$

The other points taken on the diagram have also been checked up by this loss method, and the results are shown in Table I., from which it will be seen that they are practically the same. The curves shown in Fig. 5 represent the performance of the motor at different loads, and have been worked up from the losses in the manner described above. The advantages attending the use of the circle diagram for determining the performance of an induction motor are: (1) That all errors common to the method of calculating the various data from the losses are obviated; (2) that the diagram indicates the most suitable application of the motor, so far as its operating characteristics are concerned; (3) that any defects which may exist in the windings are indicated by the magnitude and phase relation of the current vectors. When a motor has a high secondary but normal primary resistance the power factor of the short-circuit current will be high, but that of the no-load current will be normal. These facts indicate that a motor has a high slip, also a high starting but normal maximum torque and low efficiency. On the other hand, with a high primary and normal secondary resistance, the no-load current will be normal, but the short-circuit current will be low; and, although both power factors will be high, that of the no-load current will have the higher

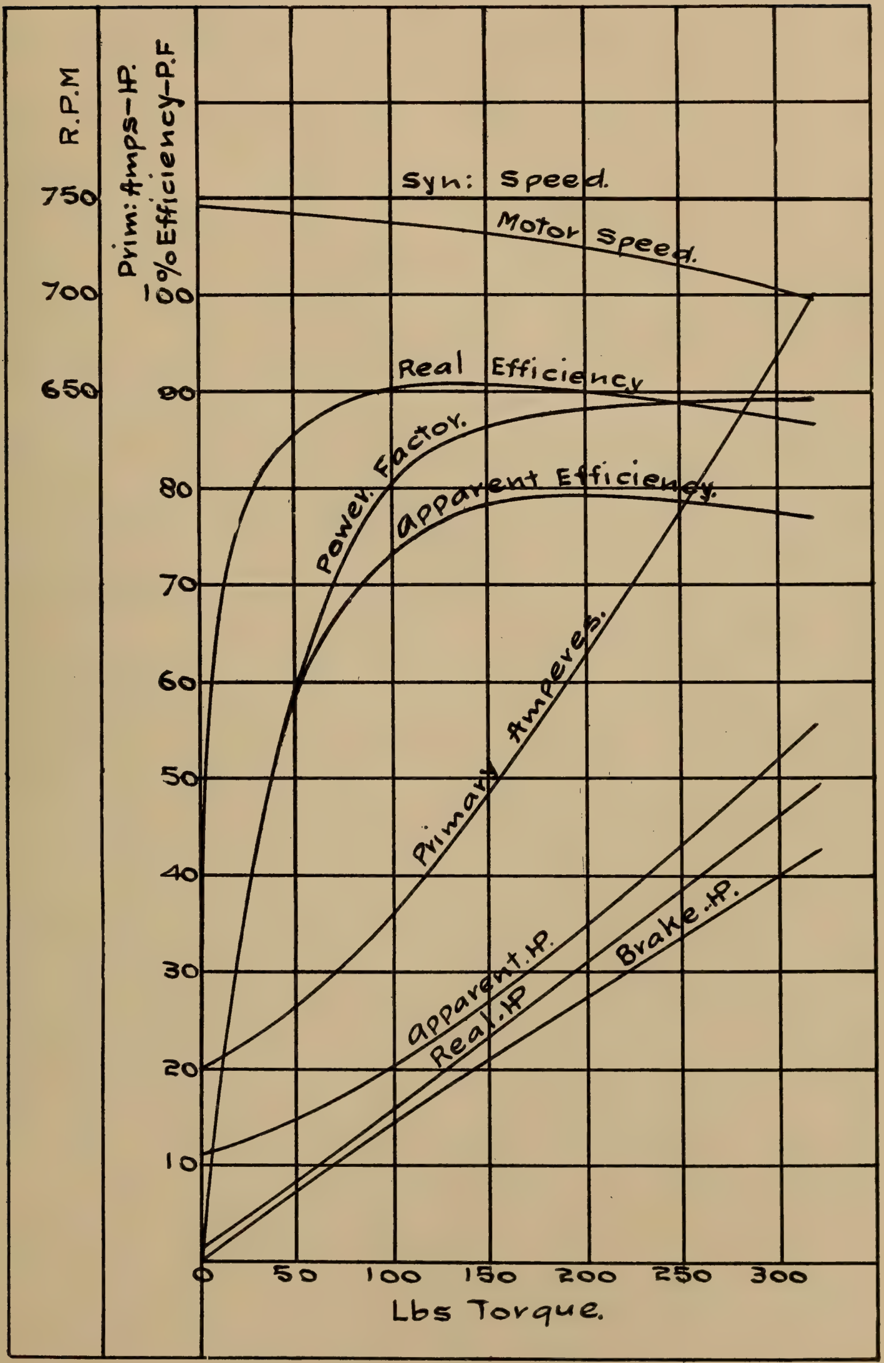


FIG. 5.—MOTOR PERFORMANCES AT VARIOUS LOADS

TABLE I.—COMPARISON OF DIAGRAM AND CALCULATIONS

| Total Amperes. | Apparent H.P. | Data from Vector Diagram | | | | | | Data calculated from Losses. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Power Factor | Real H.P. | Brake H.P. | Real Efficiency. | % slip. | Lbs Torque. | Power Factor. | Real H.P. | Brake H.P. | Real Efficiency. | % slip. | Lbs Torque. |
| 100 | 55·7 | 89·2 | 49·5 | 42·6 | 86 | 6·4 | 320 | 89·2 | 49·6 | 42·7 | 86·2 | 7· | 322 |
| 67·5 | 37·6 | 88·7 | 33·2 | 29·6 | 89·2 | 3·92 | 216 | 88·3 | 33·2 | 29·8 | 89·6 | 4· | 217 |
| 45 | 25 | 83·5 | 20·8 | 18·9 | 90·5 | 2·35 | 136 | 84 | 21· | 19·1 | 90·8 | 2·2 | 137 |

value, in which case the efficiency, starting, and maximum torques will be low, due to a large primary drop. When the no-load current is large compared to the short-circuit current, and the power factor of the latter is abnormally high, this may be taken as an indication that some coils are reversed. If the number of turns in a winding are insufficient or some of the coils have become short circuited, the no-load and short-circuit current vectors will be much above their normal value, but their power factors will be low.

Referring to the performance curves in Fig. 5, it will be seen that the power factor rises rapidly and is fairly high at light loads, but a high power factor may be taken as an indication that the maximum torque is not great. The efficiency curve also rises rapidly, which indicates that the no-load loss is small compared to the variable losses. The performance curves of this motor show that its maximum efficiency occurs at about three-quarter load, which indicates good all-round performance.

In conclusion, it will be seen that the circle diagram affords a quick and accurate method of determining the performance of induction motors, and is also of great assistance in design.

# DIAGNOSING AN INDUSTRIAL DISEASE

By **H. F. J. Porter**

## III.—METHODS OF REDUCING CONGESTION

THE quality of the government of a democratic or self-governing community is determined largely by the knowledge of and interest in the subject displayed by the majority of its members. For instance, in a city like New York, where a large percentage of the population is composed of foreigners, many of whom are ignorant of our ways and even of our language, and another large percentage is composed of those who, being immersed in their own affairs, take no interest in public matters, it happens that another element, which takes a natural interest in public affairs and possesses a natural aptitude for organization and management, tries to make it their business to run the government, and actually succeeds in doing so to the extent that the above-mentioned majority, through ignorance and lack of interest, allows.

So it happens that the affairs of the community are affected by the selfish interests of those who obtain the reins of government or of those who influence them to their way of thinking. In order to obtain, therefore, a successful democracy—i. e., a government of the people for the people and by the people—it becomes necessary to develop the intelligence of the majority and to instruct them in public affairs by the principal means of education which we possess, and which are our public schools for the children and the rostrum and the daily press for adults; then, as the people acquire knowledge, the importance of attending to their own interest becomes impressed upon them and they give more thought to public matters.

In a city like New York, where so large a majority of the population is being continuously augmented by an ignorant foreign immigration, it is impossible to instruct them as rapidly as their numbers increase, and so the housing and industrial conditions and surroundings of these people are not brought to the attention of the general public until after the more enlightened of the working element is taught to express itself, or until those conditions become so bad that they bring themselves to the cognizance of the public.

The industrial disease, which has been under diagnosis for some time past owing to the fact that it has become so acute as to make itself obnoxiously apparent, has, during the past few months, received considerable clinical investigation, resulting in certain legislative recommendations, many of which have been formulated by the Mayor's Commission on Congestion of Population in a report recently issued.

The report says that the congestion of people in certain sections of the city is due initially to the establishment here of certain industries of the type engaged in the manufacture of light products, such as clothing, millinery, laundry work, printing and paper goods, metals, machines and conveyances, food, liquor, tobacco, leather and rubber goods, and wood articles, etc., not involving the operation of heavy machines. The attractions of these industries to the city are the convenient factory lofts, with heat, light and power on tap, the proximity of the supply of raw material and labour and the convenient access, not only to the local market, which in itself is large, but to the larger market of the world through the buyers from elsewhere, who come to New York to obtain supplies.

The Committee on Factories says that one of the most marked features of this congestion is the great concentration of factories in lower Manhattan. Out of approximately three-quarters of a million factory operatives in Greater New York there are more than two-thirds, or half a million, working below Fourteenth street on the East Side and below Twentieth street on the West Side of the city, while a hundred thousand are included in the central manufacturing zone above Fourteenth street.

A committee of the State Conference on Charities and Corrections has reported that a minimum income of $800 per year is necessary to support a family in New York on a reasonable basis, without allowing any saving. The average wage of the factory operatives of the sections referred to is less than $537.

It is shown that, owing to the early hour of starting work (7 A. M.), the long hours of work, and the poor transportation facilities, these operatives are compelled to live near their places of occupation. This concentration of these operatives' families in a limited area causes high rents for living quarters, and, consequently, small quarters for each family, which is coupled with low wages for the operatives, on account of the over-supply.

The industries themselves are very fluctuating in the amount of business they do at different seasons of the year, and the operatives have to take in boarders or do tenement contract work to tide themselves over the dull periods.

There is also a concentration of office buildings in lower Manhattan, and each of these—some with a capacity of from five to ten thousand people—requires a large number of employees for maintenance and attendance, these being added to the resident population of the district.

These conditions have a very deleterious effect physically, morally and mentally on those involved, and, consequently, are economically wasteful and costly to the city.

For relief from the above conditions the committee recommends better and stricter enforcement of sanitary standards in factories and tenements and a later hour for starting work. By the latter means operatives who would not have to start work until 8 o'clock could live at a distance, and need not start from their homes until 7 o'clock. The extra cost of transportation would be made up by a saving through cheaper rents, less medicine and doctors' bills, and an increase in income from more continuous work, due to better health.

The Commission recommends, also, better transport facilities, in order to allow operatives to live at a greater distance from their work. It recommends, further, a distribution along the river fronts of factories whose product is intended for local consumption, making a factory belt around the city which should be threaded by a belt transport system, not only for the conveyance of people, but for the movement of freight.

It advocates in this connection the removal of factories whose product is intended for outside markets, together with the operatives' homes, from the city to the suburbs, under laws governing building construction and insuring attractive neighbourhood conditions and adequate housing facilities. It calls attention to the fact that compensation must be given to the operatives for the loss of the attractions of city life by providing recreation, amusement and education.

In addition to the above, greater truck accommodation would be needed and lower truck charges on ferries, to lessen the cost of transportation to the city of goods manufactured in the suburbs.

The Committee on Labour and Wages advocates several steps to put the above recommendations into execution, maintain them, and see that present conditions are not repeated. It advocates:

First, owing to the preponderance of the factories of New York State in New York City (of the 40,000 in the former 30,000 are in the latter), that the scope of the State Department of Labour be expanded (a) by the appointment of a Deputy Commissioner of Labour for the city, who will devote his time to the direction and supervision of the department's work in the city; (b) that, as the present force of thirty-five factory inspectors assigned to the city is able to visit each of its factories only once a year, this force be increased to an adequate number; (c) that appropriate legislation be passed to enable the new organization to carry out its functions.

Second, as there are wage and other disputes constantly occurring between employers and employees which frequently lead to lockouts and strikes, entailing losses to both and inconveniences and expenses ultimately borne by the public, there should be an industrial commission, composed of three members, one to be nominated by the unions, one by the manufacturers and the third by the Mayor, and all to be appointed by him. The duties of this commission should be to investigate (a) the labour conditions and wages of the operatives, and (b) disputes before and after lockouts and strikes. The object of such investigation would be to delay the lockout or strike until after the validity of the dispute had been determined and a decision regarding it had been made public. This would be in order to establish public sentiment, which ultimately settles these matters.

Third, as none of these fluctuating industries pays sufficient wages to support its operatives through its dull season, and as there are some industries existing, either in the city or elsewhere in the State, which, owing to oppositely timed seasonal fluctuations, are seeking operatives when those in the city are idle, the latter can find work, if apprised of it and enabled to reach it, it is, therefore, advocated that municipal employment offices be established in other cities of the State, as well as in this city, for the purpose of bringing the demand and supply together.

Fourth, in order to make this movement as broad as possible, it is advocated that a National Department of Labour be established, with a secretary who shall be co-ordinate with the Secretary of Commerce and Labour in the President's Cabinet.

It is desirable that immigrants newly arriving should not, through their ignorance of our ways, wages and conditions of work, be allowed indiscriminately to disturb, by their sudden presence in a settled community, the industrial balance which fortunately existed, while it would be desirable to have them go to a locality where their presence might be very necessary for the settlement of its industrial problems. Therefore, the duties of this National Department of Labour would be (a) to give wide publicity throughout the country to the opportunities for work, conditions of labour, wages paid, and permanency of employment, etc.; (b) conditions of unemployment; (c) standard hygienic and sanitary conditions of factories; (d) the same information regarding housing, together with the location of homes within walking distance of occupation or transit facilities; (e) cost of main staples of consumption, to encourage thrift and economic living; (f) public school opportunities; (g) social and recreational opportunities; (h) general labour information as to open, closed and union shops.

The Commission recommends: (a) that the rate of taxation upon all buildings be half the rate of taxation of all the land, and that this reduction be secured by an equal charge in each of five consecutive years.

(b) An unearned increment tax. The principal argument advanced in support of the imposition of such a tax is that in nearly every instance where real estate values have increased it has been due wholly to public improvements and to the general development of the city, and in no way to action on the part of the property owner. This recommendation comes from the successful operation of the adoption of a similar method of taxation in Germany, where it discouraged land speculation, forced land into use, and encouraged building.

Within a few weeks a very acute symptom of this industrial disease has made itself apparent by a serious fire in a shirtwaist factory in one of the loft buildings in the Fifth avenue manufacturing zone of New York, where, although late on Saturday afternoon, when usually all work in these buildings is finished, the lives of 146 working people were lost through their inability to escape from the premises.

Investigation has shown that the proprietors of this factory were ignorant of modern methods of efficient management and totally indifferent to the interest of their employees and of the public; that they paid no attention to the city ordinances or the State laws intended to safeguard the health and lives of their working people, even after being admonished that conditions in their premises were unsanitary and unsafe.

A long, serious and expensive strike instituted several months ago against this firm by its employees failed in its intended purpose to improve conditions, and the latter continued to be as bad as before. It was the continuance of these conditions which brought about the disastrous fire, and the lethargy of the public has at last been broken.

Mass meetings have been held, resulting in the appointment of a standing Committee on Safety, which will investigate, not only fire, but sanitary conditions in factories, and apply the results of the findings of experts whom they may engage to the enforcement of old and the establishment of new legislation for the betterment of those conditions. This committee is composed altogether of people who will give their time and means voluntarily to the subject, and so will be able to work independently and unhampered by limitations. The Women's Trade Union League has asked for legislation for the appointment of an Industrial Bureau, to see that proper legislation is instituted and enforced, and it is expected that between these two bodies this industrial disease will be held in check and materially modified in intensity.

# FUEL RESOURCES OF THE UNITED STATES

PRESENTED WITH THE APPROVAL OF THE DIRECTOR OF THE UNITED STATES BUREAU OF MINES

By **Robert H. Fernald**

THE reports of the United States Geological Survey show that, if the rate of increase in the fuel consumption that has held for the past fifty years is maintained, the supply of easily available coal will be exhausted before the middle of the next century. Another estimate places a 75-year limit on the anthracite coal supply and a 200-year limit on the bituminous supply.

This condition of affairs points to the necessity of utilizing grades and varieties of fuel which have not until recently been considered as commercially possible.

It is desired to point out the possibilities to be found in

(a) Low-grade or high-ash fuels which are at present regarded as practically worthless;

(b) Extensive deposits of lignite found in various sections of the country;

(c) Swamps and bogs covering vast areas containing peat.

In 1907 the coal mined in the United States amounted to over 480 million short tons. The distribution of this coal by States, as recorded by the United States Geological Survey, is shown in Fig. 1.

In this connection it is of interest to note the distribution of the coal mined by different countries for the same year, Fig. 2.

The annual rate of increase of fuel consumption in the United States shown by Fig. 3 is the basis of the statements of the first paragraph relating to the possible exhaustion of our fuel resources.

It is, of course, claimed by some that, although the industries of the country are steadily increasing, both in size and number, it is not reasonable to expect the annual rate of increase in fuel consumption which has prevailed for the past fifty years to continue, and that the figures sent out by the Geological Survey are those of alarmists.

It is not important for this discussion that this phase of the question be further considered, as the situation is sufficiently urgent in any case to require careful consideration of our future possibilities in the way of more economical use of the present available fuels not now accepted as marketable.

One of the most serious problems at the present time is due to the fact that, on the average, nearly 50 per cent. of the coal in the mines is left either in or at the mines and is inaccessible for the future generations. For example, in 1907 approximately 400 million tons of coal were left in or at the same mines from which the 480 million tons were taken.

To stimulate the possible use of various grades of fuel and safe and successful methods of mining much material at present left in the mine are some of the problems of the United States Bureau of Mines. Problems of combustion are being carefully studied by means of stationary boiler plants, house-heating boilers and a long combustion chamber; proper classification and relative prices for coals, by means of specifications and purchase by contract; and more economical use and utilization of fuels heretofore not regarded as adapted to such purposes by means of briquetting, coking and producer-gas plants.

A study of the results of these

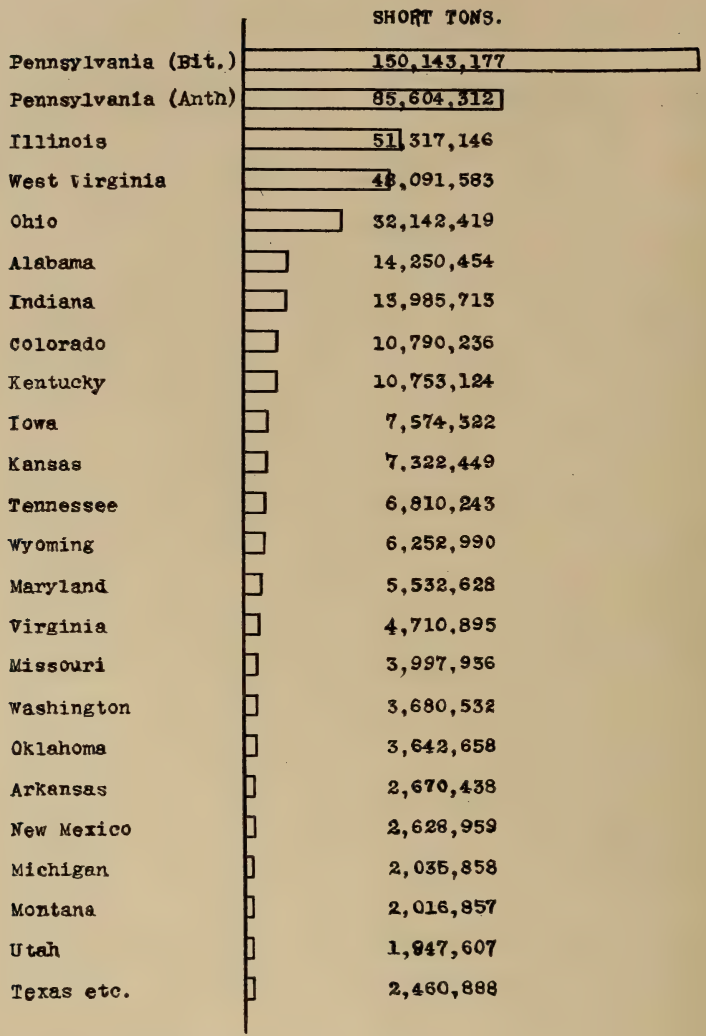


FIG. 1.—PRODUCTION OF COAL IN THE UNITED STATES, IN 1907, BY STATES.

various investigations, although extremely profitable and interesting, would be deviating too far from the purpose of this paper, and attention is, therefore, especially directed to the use of fuels outside of the regulation list of ordinary commercial grades.

### HIGH-ASH COALS

By means of the gas producer and gas engine high-ash fuels have been used for power development with the economy shown in Fig. 4. As a basis of comparison, the results secured from a high-grade West Virginia coal, both in the steam plant and producer-gas plant, are indicated in Fig. 4, at (a) and (b), respectively.

The average analyses of this fuel give:

| | Per Cent. |
|---|---|
| Moisture | 2.97 |
| Volatile matter | 29.55 |
| Fixed carbon | 65.04 |
| Ash | 2.44 |
| | 100.00 |
| Sulphur | 1.13 |
| B. t. u. per pound dry coal | 15,048 |

The tests of this fuel in the steam plant were made with a 210 horse-power Heine boiler and a simple, non-condensing, 250 horse-power

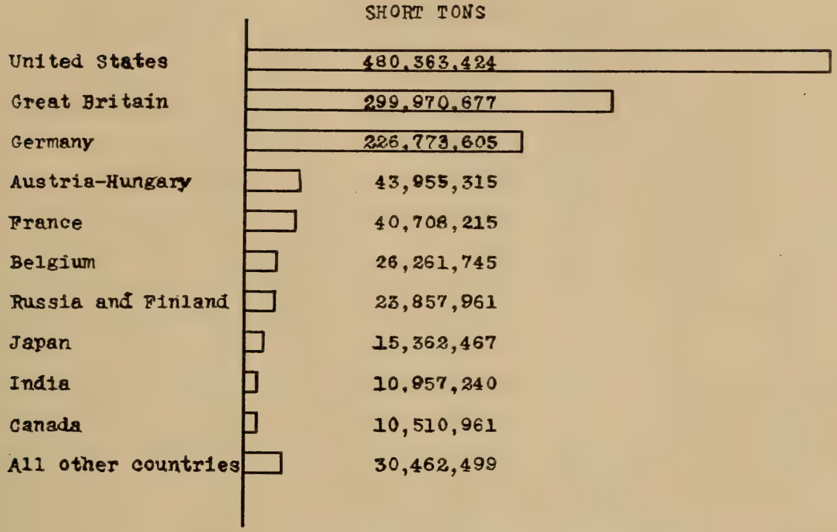


FIG. 2.—WORLD'S PRODUCTION OF COAL IN 1907.

Corliss engine having a water rate of 26.6 pounds per I. H. P.-hour.

The tests in the producer-gas plant were made with an R. D. Wood pressure producer and a 3-cylinder, vertical, single-action, 235 horsepower Westinghouse gas engine.

Coals containing as high as 44 per cent. ash, roofing slabs, Illinois and West Virginia bone coals, washery refuse and Rhode Island graphitic anthracite, all practically valueless for steam furnaces, have thus been successfully used for power development.

This low-grade fuel problem is receiving careful consideration in Europe, although the number of installations utilizing the so-called refuse material is small. Two years ago I was able to find only two such plants, one using roofing slabs containing 60 or more per cent. refuse and the other a combination of roofing slabs, culm and washery refuse, averaging 53 per cent. ash.

## LIGNITE

The lower grades of lignite are not very satisfactory for steam furnaces,

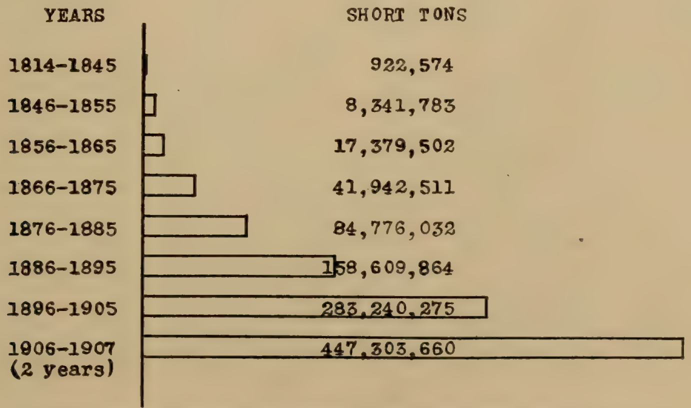


FIG. 3.—AVERAGE YEARLY PRODUCTION OF COAL FOR EACH DECADE IN THE UNITED STATES SINCE 1814.

| Fuel from | Variety or size | Percent ash | Percent moisture | Lbs. consumed in producer per B.H.P. per hour. Fuel as fired. |
|---|---|---|---|---|
| West Virginia | Run of mine | 2.44 | 2.97 | 2.90 Standard "a" |
| New Mexico | Run of mine | 19.63 | 3.62 | 1.10 |
| Tennessee | Run of mine | 20.57 | 3.55 | 1.45 |
| Iowa | | 20.70 | 16.69 | 1.56 |
| Wyoming | | 20.72 | 9.44 | 1.70 |
| Wyoming | Run of mine | 21.73 | 8.65 | 1.83 |
| Illinois | Bone | 23.12 | 8.67 | 2.88 |
| Brazil, S.A. | Run of mine | 23.44 | 10.96 | 2.02 |
| West Virginia | Bone | 28.08 | 2.91 | 1.26 |
| Pennsylvania | Washery refuse | 30.35 | 2.68 | 2.34 |
| Pennsylvania | Washery refuse | 31.89 | 2.25 | 2.76 |
| West Virginia | Bone | 43.74 | 0.47 | 1.65 |
| West Virginia | Run of mine | 2.44 | 2.97 | 0.87 Standard "b" |

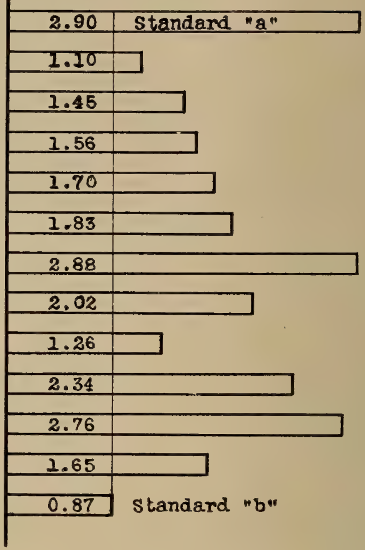


FIG. 4.—RESULTS FROM HIGH-ASH AMERICAN BITUMINOUS COALS.

but they are in general use in gas-producer installations, having proved excellent gas fuels. The relative values of the low-grade lignites of North Dakota and Texas in the gas producer, as compared with the same high-grade West Virginia coal previously used for comparison, both for the steam and gas plants, are brought out in Fig. 5.

Through the utilization of these lignites, beds underlying from 20,000,000 to 30,000,000 acres of public lands, supposed to have little or no

| Fuel from | Variety or size | Percent ash | Percent moisture | Lbs. consumed in producer per B.H.P. per hour. Fuel as fired. |
|---|---|---|---|---|
| West Virginia | Run of mine | 2.44 | 2.97 | 2.90 Standard "a" |
| Texas | Run of mine | 8.87 | 32.20 | 2.17 |
| North Dakota | Run of mine | 11.42 | 32.64 | 2.27 |
| Texas | Run of mine | 10.36 | 33.50 | 2.54 |
| Texas | Run of mine | 7.28 | 33.71 | 1.98 |
| Texas | Run of mine | 7.45 | 34.08 | 2.16 |
| North Dakota | Run of mine | 6.45 | 35.78 | 2.63 |
| North Dakota | Run of mine | 5.04 | 36.13 | 2.26 |
| North Dakota | Run of mine | 6.36 | 39.56 | 2.91 |
| West Virginia | Run of mine | 2.44 | 2.97 | 0.87 Standard "b" |

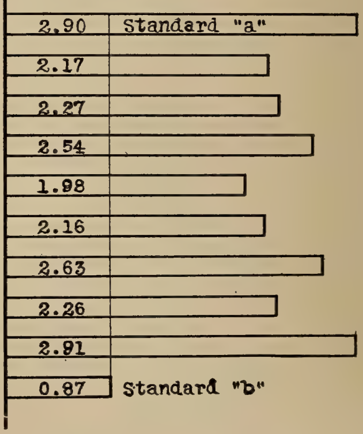


FIG. 5.—RESULTS FROM AMERICAN LIGNITES.

| Fuel from | Variety or size | Percent ash | Percent moisture | Lbs. consumed in producer per B.H.P. per hour. Fuel as fired. |
|---|---|---|---|---|
| West Virginia | Run of mine | 2.44 | 2.97 | 2.90 |
| Florida | Air dried | 5.17 | 21.00 | 2.43 |
| N. Carolina | Air dried | 13.88 | 27.78 | 3.37 |
| West Virginia | Run of mine | 2.44 | 2.97 | 0.87 |

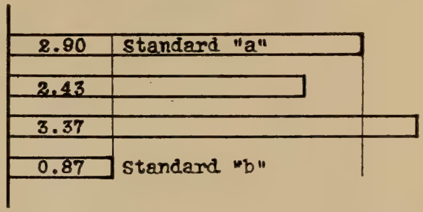


FIG. 6.—RESULTS FROM AMERICAN PEAT.

commercial value, have been shown to increase the money value of the government's own property to the extent of probably $300,000,000 or more.

The extensive supply of lignite in districts possessing no coal may thus lead to industrial development in States not now recognized as manufacturing centres.

### PEAT

The use of peat for domestic purposes in European countries dates back several hundred years, but the extensive development in methods of mining and utilizing peat has been largely within the past ten years. At the present time in many of the European countries peat is a large source of power development through the aid of the gas producer and engine, and the utilization of the peat bogs is becoming general. Some idea of the extent of this development may be had from the statement that Russia alone mines annually over 5,000,000 tons of dry peat.

It is estimated by the United States Geological Survey that the bogs of this country contain approximately 12,888,000,000 tons of dry peat commercially available. At a market value of $3 per ton for machine peat bricks, this represents over $38,600,000,000.

The Canadian Government is carrying on extensive researches relating to the use of peat, as this fuel is found in very large areas in Canada.

A few samples of peat have been used for the production of producer gas at the testing station of the United States Bureau of Mines.

Using the same West Virginia coal, the relative results of two of these tests are shown graphically by Fig. 6.

The cost of preparing peat for the market is comparatively small. Reliable figures are not available for the United States. For one locality in Sweden, visited in 1908, coal cost $3.75 per ton, and peat, delivered on the operating floor, 80 cents per ton.

### CONCLUSION

The utilization of these fuels, which have previously been regarded as of little or no value, may thus increase our fuel resources approximately (on the basis of present marketable grades):

| | Per Cent. |
|---|---|
| (a) Low-grade bituminous and anthracite... | 75-100 |
| (b) Sub-bituminous, lignite and peat....... | 60 |

or, roughly, a total of 150 per cent. over our present supply of marketable grades of fuel.

In considering the use of such fuels it must not be overlooked that the percentage of ash is high in the low-grade bituminous and anthracite fuels and the percentage of moisture high in many of the lignites and in the peats. These conditions practically prohibit transportation and necessitate the use of these grades in close proximity to the mine or bog.

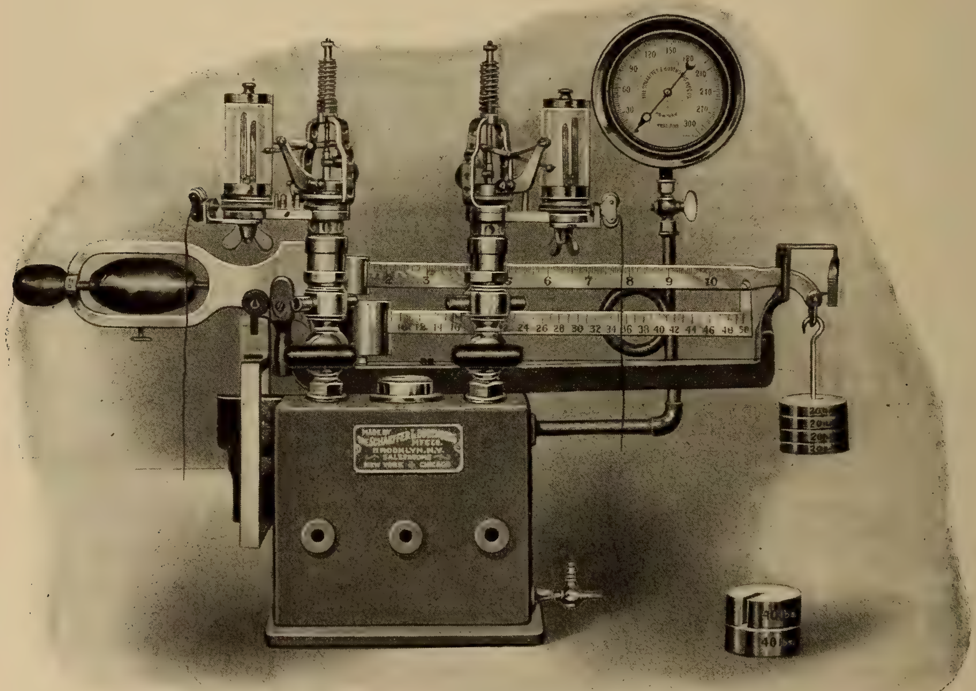
# DETERMINING THE ACCURACY OF INDICATOR SPRINGS

By E. K. Uebe

THE indicator has been described as an instrument which bears to the work of the engineer the same relation which the stethoscope does to the physician. It is conceded to be absolutely necessary to the operating engineer, and its value can hardly be overestimated.

The indicator diagram furnishes the only known means for ascertaining the action of the steam in the cylinder of an engine, enabling its efficiency to be determined and the internal wastes detected. Under such circumstances it is of vital importance that the accuracy of the instrument be unquestioned, and any suspicion of inaccuracy in the indicator casts suspicion upon all the diagrams which have been made by it.

Since the indicator is really a special form of recording pressure gauge, it is evident that the spring by which the varying pressures in the cylinder are measured must be entirely reliable and correct. While every care is taken in the original production of the springs used for this purpose, the only method to be assured of their accuracy is to sub-



INDICATOR TESTING APPARATUS.

ject them to test in the completed instrument.

A special apparatus for testing indicator springs has been designed and is made by the Schaeffer & Budenberg Manufacturing Company, of Brooklyn, N. Y., the general arrangement of which is shown in the illustration. The principle upon which this apparatus is made is that of weighing the pressure upon a piston of known area, employing accurate scale beams instead of springs, and thus furnishing a thoroughly scientific basis for comparison and calibration.

The testing apparatus consists essentially of a closed vessel of cast iron, capable of resisting internal pressures up to 200 pounds per square inch. To this chamber there is fitted a cylinder containing a piston of precisely one-half a square inch in area, the piston being free to move vertically in the cylinder. The lower portion of the piston is pointed, and rests in a yoke, which is suspended on the knife edge of a scale beam mounted on top of the pressure chamber. If the scale beam is previously balanced before the steam pressure is admitted into the chamber, it is evident that the reading on the scale required to counterbalance any pressure will give the pressure acting on each element of the chamber equal in area to that of the piston. The scale beam is graduated to fiftieths of a pound, enabling very precise and accurate readings to be made.

In testing indicator springs, the steam is turned into the pressure chamber to cause it to be warmed gradually, and by blowing through the connections and indicator cocks any particles of grit or dirt which may have accumulated is removed. The steam is then shut off, and the indicator to be tested is screwed in place, the drum having paper placed upon it with vertical lines 1—2, 3—4, as shown in the accompanying diagram. The indicator pencil is then placed in contact with the paper on the drum, and a horizontal line *Q—Q* drawn, marking zero pressure The poise on the scale beam is ten set at five pounds, and steam admitted into the chamber until the beam floats. When the pressure is exact, the line *R—R* is drawn, and so on for successive pressures of five pounds, until the limit of the scale is reached. During this operation the motion of the indicator pencil is kept continuously upward, and if at any moment the pressure rises too high, it is lowered by manipulating the valve below the required amount and then gradually raised to the desired point.

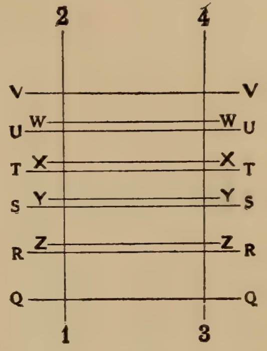


DIAGRAM OF INDICATOR TEST.

When the indicator pencil has reached its highest position the steam pressure is allowed to fall gradually, and a series of similar lines, as *W—W, X—X, Y—Y,* and *Z—Z,* is drawn during the descent of the piston, the motion being continuously downward. The distance between any two of these lines, as *Z—R, Y—S,* shows the loss due to the friction of the indicator.

The special advantage of this testing apparatus lies in the fact that the springs are tested in the individual indicator in which they are used and under actual steam pressure, as near actual working conditions as possible.

This testing apparatus may also be used for testing pressure gauges, there being separate openings provided for this purpose, besides a standard test gauge for comparison.

# AUTOMATIC TRAIN-STOPPING DEVICES

IT has long been realized that, with the increasing speed and frequency of trains, and with the strain upon locomotive engineers due to the corresponding increase of responsibility, there should be some positive and mechanical appliance to aid in insuring observance of the warning of signals. The modern block system is perfect in theory and complete, mechanically, until the man himself is reached, and at that point the human and fallible element enters, and with it the possibility of failure and disaster. When the signal is set at clear, the train is permitted to proceed at full speed, and when it is set at danger the train is supposed to be stopped. Unless some automatic mechanical appliance is used, this stopping of the train must be effected by the engineer himself; and if, for any reason, voluntary or involuntary, he does not act, the whole protective value of the signal system is ineffective. These facts have caused many engineers to devise automatic apparatus which shall act without human intervention if the engineer fails to heed the warning of the semaphore, and, while the construction of such a device seems simple at first glance, practical experience has shown many difficulties to be surmounted if reliable action is to be insured.

Mechanical tripping devices, raised from the ground to a position where they engage with a projection on the locomotive when the signal itself is set at danger, have been found liable to derangement from many causes, and especially are they unreliable and ineffective in the stormy weather of the winter season. At the very time when trains are delayed and disorganized by heavy snows, such devices, with moving parts close to the ground, become unreliable and ineffective, and so fail to meet the requirements. Other so-called automatic devices involve the use of electric currents, with insulation of important parts of the machinery and track, rendering them undesirable to be exposed to the rough usage and varying climatic conditions inevitable in active railway service.

Under such a state of affairs it is not to be wondered that railway men have been distinctly skeptical as to the practicability of producing an automatic train-stopping device which

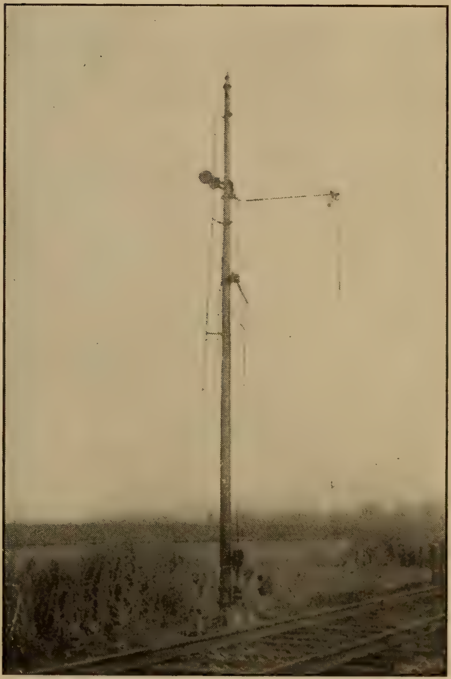
HARRINGTON SAFETY STOP, IN CLEAR POSITION.

TRAIN STOPPED BY HARRINGTON TRIPPING DEVICE.

should be free from these objections, and which should be found operative at all times, independently of rains, snows, or casual obstructions upon the ground.

One of the more recent devices for adding to the safety of railway travel by eliminating the personal element in block signaling is that devised by Mr. S. H. Harrington, of New York, and this simple apparatus has given such good results in practice that it is worthy of attention. In this design the safety device is wholly above the ground, being suspended from a pole alongside the track far above anything which could interfere with its action. The suspended portion of the apparatus consists of a weight, formed of a short iron bar, hanging from a chain in such a manner that it will strike against a horizontal transverse lever attached to the roof of the cab of the locomotive, moving the lever and causing a service application of the air brakes throughout the train, besides sounding a whistle to alarm the engineer. When the signal is set at clear, the suspended weight is lifted high enough to clear the lever on the locomotive, and the engine passes on without interference. The weight is heavy enough to act by inertia, thus avoiding any rigidity, and thus the apparatus is free from disturbing influences.

Experience with this form of automatic-signal control has shown its reliability and success. By attaching the apparatus to the distant signal, or to a pole 1,000 feet in advance of the semaphore, the train is stopped at the signal whenever it is set at danger, even in time of fog or storm, when the engineer may not be able to see distinctly. With such a device it is impracticable for the engineer to run past the signal, even if he is disposed to take that risk, the action being taken entirely out of his hands and placed in control of inanimate and automatic mechanism.



SAFETY STOP IN BLOCKED POSITION.

The Harrington automatic train-stopping device has been in active use on the Northern Railway of New Jersey for several years, and it has been actuated more than 1,000 times by trains attempting to run past the danger signals, demonstrating its effectiveness.

# THE BOILER ACCIDENT ON THE U. S. S. DELAWARE

THROUGH the courtesy of the Babcock & Wilcox Company, we are enabled to publish the accompanying summary of the finding of the Court of Inquiry which investigated the accident to one of the boilers of the U. S. S. *Delaware.*

To enable our readers to understand fully the finding, we may remind them that the accident occurred about 9:15 A. M., January 17, while the *Delaware* was bound for Norfolk, Va. The ship was proceeding under easy steam, but on account of poor draft the fire-rooms were closed and working under an air pressure of ¼ inch. This, under the circumstances, was not more than good natural draft, so that the rate of combustion was about 18 pounds of coal per square foot of grate. The boiler is one of the well-known Babcock & Wilcox marine type, with 4,425 square feet of heating surface and 103 square feet of grate surface, there being fourteen boilers in all. On trial, the *Delaware* developed nearly 30,000 horse-power, so that this boiler, when worked under forced draft, has a capacity of over 2,000 horse-power.

It is very interesting to note in this connection the statement of the commanding officer, made to the correspondents of the newspapers who boarded the ship upon her arrival at Hampton Roads. It appears from these statements that, although the captain was on deck at the time of the accident, he did not know that one had occurred until it was reported to him some minutes later. In other words, the explosion did not make sufficient noise to attract attention on the upper deck.

The damage was confined to Boiler "O," and the extent and nature thereof are set down in the findings in considerable detail. It is also to be noted that the structure of the vessel was not injured at all, thus emphasizing again the fact that an accident to a water-tube boiler involves the minimum of damage. The boiler was repaired while at Norfolk with some new headers and new tubes, most of the work being done by the engineering department of the ship.

There is one point in the finding which needs just a word of explanation to make it perfectly clear. The court finds that only the outboard half of the boiler was damaged. It might seem at first glance as though it would be impossible for one-half of the boiler to be injured and the other escape. The explanation, however, is very simple. The feed-water enters the boiler in the steam-and-water drum, which is above the front headers and connected to them by nipples, and is discharged through an internal feed pipe perforated with holes on its lower side. This pipe extends from the check valve at the inboard end of the drum to a short distance past the centre of its length. As long as the water in the drum was above the tops of the nipples mentioned it would not, of course, make any difference where the feed-water was introduced, as it would, naturally, find its level. In case of low water, however, due to inadequate feed, there might be, under moderate combustion, just enough water to save the inboard half of the boiler, where the water would go directly down the nipples, while only a few headers and associated tubes on the other side would get any. This appears to be the explanation of the salvation of the inboard side of the boiler.

With this general statement of the surrounding conditions we believe the finding of the court will be entirely clear, and it seems to us that the court is to be congratulated on the very careful analysis which they have made of all the circumstances of the case, so that the reasons for their conclusion that the accident was due to low water are perfectly evident and convincing.

NAVY DEPARTMENT.
BUREAU OF STEAM ENGINEERING.
WASHINGTON, D. C.
MARCH 11, 1911.

*Subject: "Delaware" Boiler Explosion. Finding of Court of Inquiry.*

GENTLEMEN:

1. In compliance with the request contained in your letter of February 24, and with the approval of the Department, the Bureau submits for your information the following general statement of the finding and opinion of the Court of Inquiry appointed to inquire into the accident to boiler "O" of the *Delaware.*

(a) An explosion occurred in boiler "O" January 17, 1911, by which three rear headers, Nos. 8, 9 and 10, were blown bodily out of the boiler.

(b) These headers were found severely bowed, their tube faces were bulged, and the metal showed signs of overheating. All the back headers of the outboard half of the boiler, thirteen in number, were more or less bowed, the degree of distortion diminishing toward the outboard side of the boiler.

(c) The inboard half of the boiler was uninjured, and subsequent comment refers only to the outboard half.

(d) The 4-inch tubes next the fire were all more or less bowed near the back ends, and showed signs of having been burned; and the majority of the 2-inch tubes were more or less distorted, while a number showed signs of having been white-hot.

(e) The front headers were in good condition.

(f) The superheater tubes and manifolds showed a red colour, and the 4-inch tubes through the first and second passes showed the blue colour characteristic of overheating.

(g) On two of the headers blown out were found scores and dents made by the headers striking obstructions. The character of the scores and dents, and the blue colour of the metal in the scores, indicated that the metal of the blown-out headers was in a softened condition, due to heat, when they struck.

(h) The three headers showed unmistakable signs of having been very hot. They showed the characteristic blue colour following overheating, and the tube face of each had been bulged out by internal pressure, possible only when the metal is heated to a condition approaching redness.

(i) The greatest heat appeared to have existed at about the width of the height of the header, but the effects of overheating were manifest in all the back headers of the outboard half of the boiler, diminishing either way from the zone of greatest intensity of heat, which appeared to exist opposite the headers that were blown out.

(j) A number of 2-inch tubes of the blown-out headers gave evidence of having been white-hot. The surface of these tubes, near the back ends, appeared burned, and was covered with a coating of black oxide of iron. Signs of overheating were also in the outboard half of the drum, from which much of the soot had been burned off.

(k) From a consideration of the preceding facts, the Court concluded that the explosion was due to the lack of a sufficient quantity of water in the boiler, and that the water-tender on watch at the time was responsible for this condition. This opinion was strengthened by the fact that it was possible to enter the fireroom with safety a very short time after the explosion occurred, which would not have been possible had the boiler contained the normal quantity of water.

(l) All testimony showed that the boiler was in good condition prior to the accident, and that the regulations regarding the care and preservation of boilers had been carried out; that other boilers which had been subjected to the same use were in good condition, and that the overheating noted in the injured boiler would have produced the results observed by the Court after the accident, no matter how perfect the boiler.

(m) From some testimony before the court the conclusion was reached that the reading of the water gauges was misleading, although the gauge glass-fittings are recognized as simple and reliable; other testimony, however, led to the opinion that the opening of the feed check valve had been increased shortly before the accident occurred.

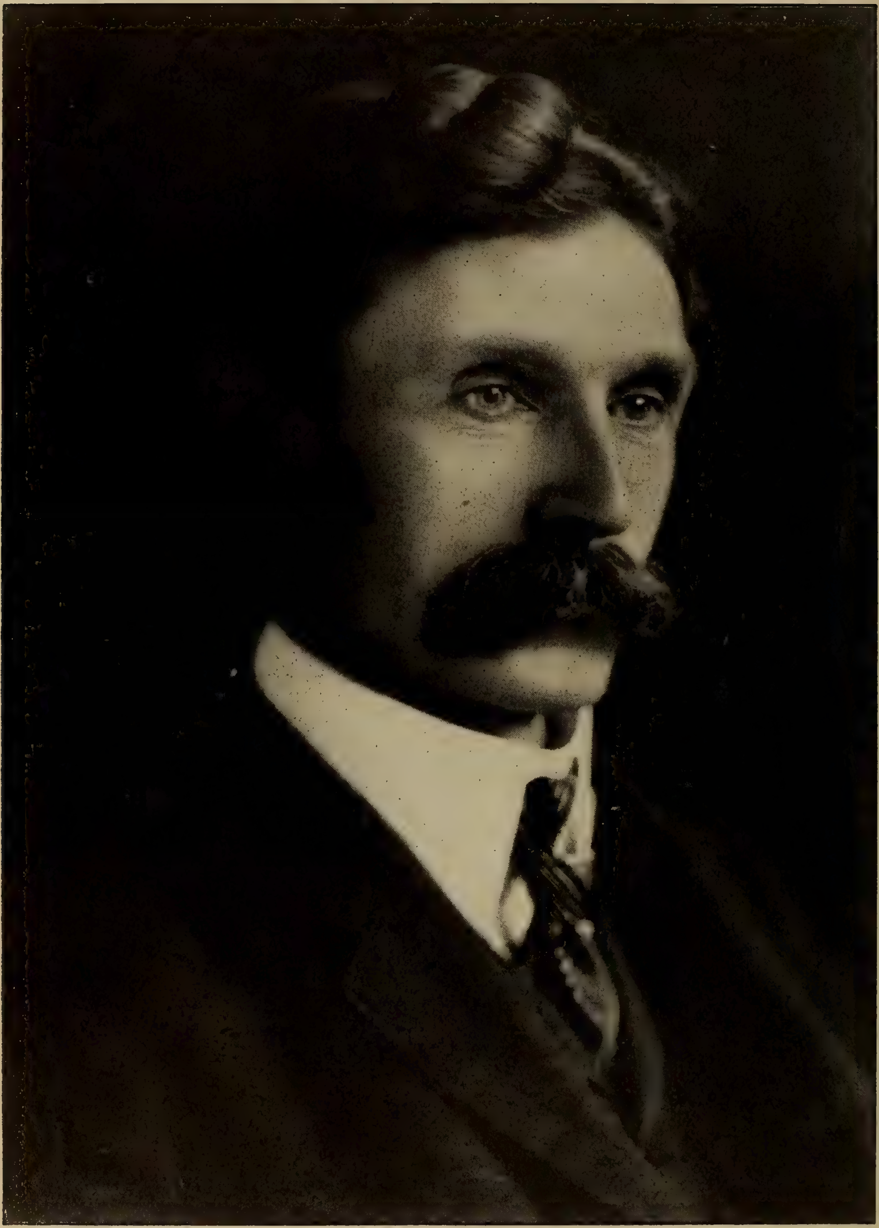
Very respectfully,
(Signed) R. S. Griffin,
*Acting Chief of Bureau.*

The Babcock & Wilcox Company,
85 Liberty Street, New York.

Joseph Austin Holmes, whose portrait we publish on the following page, occupies the responsible position of Director of the United States Bureau of Mines, and by his training and experience is extremely well equipped for the work of this recently organized Government bureau. Dr. Holmes was graduated from Cornell University in 1881, and for the ten years following his university studies he visited the important mining regions of the United States, studying their operative conditions in the course of his work as a professional mining geologist. From 1891 to 1893 he served as State Geologist of North Carolina, and in 1893 and 1894 he was occupied in the development of the Department of Mining and Metallurgy at the World's Fair at St. Louis. After the exhibition at St. Louis he served as a member of the committee in charge of the fuel tests conducted by the Geological Survey, being placed in sole charge of these investigations as enlarged and continued. From 1905 to 1910 he developed and directed the technical investigations of fuels, structural materials and mining materials under the Geological Survey.

In the course of his work he has made critical investigations of underground and surface mining conditions in the United States, Great Britain, France, Germany, and Belgium, this work including a study of accidents and methods of safeguarding the lives of miners.

He has received the degree of Doctor of Science from the University of Pittsburgh, and in 1908 he was appointed a member of the National Conservation Commission by President Roosevelt. He has also been appointed a member of the Illinois State Commission on Mining Legislation, being chosen by the Governor at the joint request of the miners and mine operators of that State. Under his direction the United States Bureau of Mines has become a most valuable feature in the development and conservation of both men and material in the mining industries of the nation.



JOSEPH AUSTIN HOLMES, D. Sc.,
Director of the United States Bureau of Mines.

See reverse side.

CASSIER'S MAGAZINE

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# REMARKABLE LOCOMOTIVES OF 1910

By J. F. Gairns

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NOTWITHSTANDING the numerous and notable developments which have occurred in the field of locomotive engineering during the last decade, there is no indication that finality is likely to be reached in the near future; for every year witnesses at least one or two developments that may be described as of an innovationary character, while each annual record includes a considerable number of new designs that are remarkable in one way or another, or which include features of particular interest to the locomotive engineer.

As regards 1910, actual novelties are few, but they are of a noteworthy character. To that year must be credited the first introduction of a turbine-electric locomotive designed for practical railway work, though its use is still mainly experimental. The year 1910 has also witnessed the construction of a locomotive designed for the unprecedentedly high steam pressure of 285 pounds per square inch and another for a pressure of 256 pounds, the two designs being, however, intended for very different duties and possessing hardly any features of importance in common. The record of 1910 also includes the initial appearance of the flexible boiler into practical locomotive engineering, the introduction of at least one wheel type that is new to the world's practice, while there are several instances of the first employment of certain types that, while not unknown, are new to the railway or country concerned.

In the matter of special features of practice the use of six-coupled wheels for passenger engines and of eight-coupled wheels in the standard goods types is becoming more and more general, though in certain fields, particularly in Great Britain, it has also been shown that the 4-4-0 type yet permits of considerable development. The situation as regards compounding is somewhat invidious. The compound locomotive is still very largely employed, taking the world's practice as a whole; but there is an increasing tendency to use four (or three) high-pressure cylinders. Superheating probably shows the greatest improvement, for this practice is becoming so extensive that it may almost be described as a standard feature of locomotive engineering all the world over. In one instance the water-tube firebox has been introduced afresh, but in a notable manner. And as regards articulated locomotives, while there have been no

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actually novel designs introduced in 1910, several particularly interesting locomotives have been constructed during that year, and one of these, probably the most interesting, is only the second engine of its class to be introduced into regular practice.

It will, therefore, be seen that the record of 1910 provides at least as many items of interest as any previous year; and when notable examples of practice that do not include actual features of novelty are also included, consideration of a large selection of remarkable designs becomes necessary.

Before dealing with specific engines it will be advisable to review briefly the situation as regards superheating; for whereas all other features of practice are more or less local in character—that is, they apply only to certain locomotives or to particular railways or countries—superheating is now a world practice. In fact, about two-thirds of the locomotives to be described or mentioned are fitted with a superheater, so that general reference to this phase of our subject in introduction will obviate detailed consideration in connection with the various engines to be dealt with.

Undoubtedly the Schmidt superheater ranks first, for it is used on about 230 separate railway systems, and just 8,000 engines are equipped with that apparatus; whereas it is doubtful whether all the other apparatuses together will account for more than another 1,000 engines. This widespread support indicates that the claims advanced in favour of superheating are not only real, but that they are also substantial, in view of initial cost of equipment and questions of repair, maintenance and reliability.

The following statistics, kindly furnished by the Schmidt Superheating Company, indicate the situation as regards superheater locomotives, according to the latest detailed figures available.

LOCOMOTIVES USING SCHMIDT SUPERHEATER

| | Number in service and under construction. |
|---|---|
| Great Britain and Ireland— | |
| London & Northwestern | 100 |
| Lancashire & Yorkshire | 50 |
| Great Northern Railway | 47 |
| London, Brighton & South Coast | 22 |
| Great Central | 11 |
| North Eastern | 10 |
| North Staffordshire | 8 |
| Great Eastern | 7 |
| Caledonian | 5 |
| Great Southern & Western (Ireland) | 3 |
| North British | 2 |
| Glasgow & South Western | 2 |
| Midland | 2 |
| Germany— | |
| Prussian State | 2722 |
| Bavarian State | 212 |
| Saxon State | 132 |
| Wurtemburg State | 54 |
| Prussian Army Administration | 32 |
| Alsace-Lorraine | 30 |
| Baden State | 15 |
| Other railways | 14 |
| Austria— | |
| State railways | 402 |
| Other railways | 63 |
| Belgium | 488 |
| Denmark | 53 |
| Spain | 101 |
| Finland | 23 |
| France— | |
| Paris-Orleans | 204 |
| Eastern | 122 |
| Northern | 88 |
| P. L. M. | 62 |
| Midi | 49 |
| Other railways | 9 |
| Greece | 9 |
| Holland | 78 |
| Hungary | 113 |
| Italy | 365 |
| Luxemborg | 1 |
| Norway | 30 |
| Portugal | 17 |
| Roumania | 57 |
| Russia | 454 |
| Sweden | 241 |
| Switzerland | 141 |
| Turkey | 24 |
| Argentine Republic | 75 |
| Bolivia | 1 |
| Brazil | 33 |
| Chili | 4 |
| Canadian Pacific Railway | 55 |
| South African railways | 23 |
| Other African railways | 14 |
| Australasia | 10 |
| India | 4 |
| French Colonies | 32 |
| Dutch Colonies | 1 |
| United States— | |
| Northern Pacific | 87 |
| New York Central | 55 |
| Chicago, Rock Island & P. | 50 |
| Great Northern | 42 |
| Minneapolis, St. Paul & S. M. | 37 |
| Chicago & Northwestern | 35 |
| Chesapeake & Ohio | 24 |
| Lake Shore & Michigan Southern | 22 |
| Chicago & Alton | 20 |
| St. Louis & San Francisco | 12 |
| Boston & Albany | 11 |
| Baltimore & Ohio | 11 |
| Chicago & Northwestern | 35 |
| Other railways | 19 |
| Japan | 36 |
| Syria | 3 |
| Uruguay | 2 |

Even these figures, which represent the latest statistics conveniently available, are not quite up to date;

for arrangements have been made for many other engines to be fitted, and there is every indication that by the end of 1911 a total of about 9,000 engines will be in use equipped with the Schmidt superheater, and that, in view of the numerous American railways which are coming into line, there will be nearly 500 separate railway systems represented.

Having thus cleared the way for consideration of specific examples of practice, it will be in order to deal with the more notable instances of the introduction of features that may be described as innovations.

During the early part of 1910 the North British Locomotive Company, Ltd., of Glasgow, constructed a turbine-electric locomotive, illustrated in Fig. 1, designed to meet the extreme conditions of main railway operation. To some extent it is anticipated by the Heilmann steam-electric locomotives tried about 1894 on the Western Railway of France and by the petrol-electric or gasoline-electric motor cars which have been introduced in a few cases for rail-motor-car traffic. But actually it is very different, and seeks to combine the advantages of the steam turbine as realized in stationary practice with the benefits of electric traction in railway service without the necessity for equipping a line with conductor rails, erecting a generating station and replacing existing steam plant. The following is a short description of the Reid-Ramsay locomotive:

Steam is generated in a boiler of the ordinary locomotive type, which is fitted with a Schmidt superheater, and the coal and water supplies are carried in the side bunkers and side water tanks at both sides of the boiler. The steam from the boiler is led to a turbine of the impulse type running at a speed of 3,000 revolutions per minute, to which is directly coupled a continuous-current, variable-voltage dynamo or generator. The dynamo supplies electrical energy of from 200 to 600 volts to four series-wound traction motors,

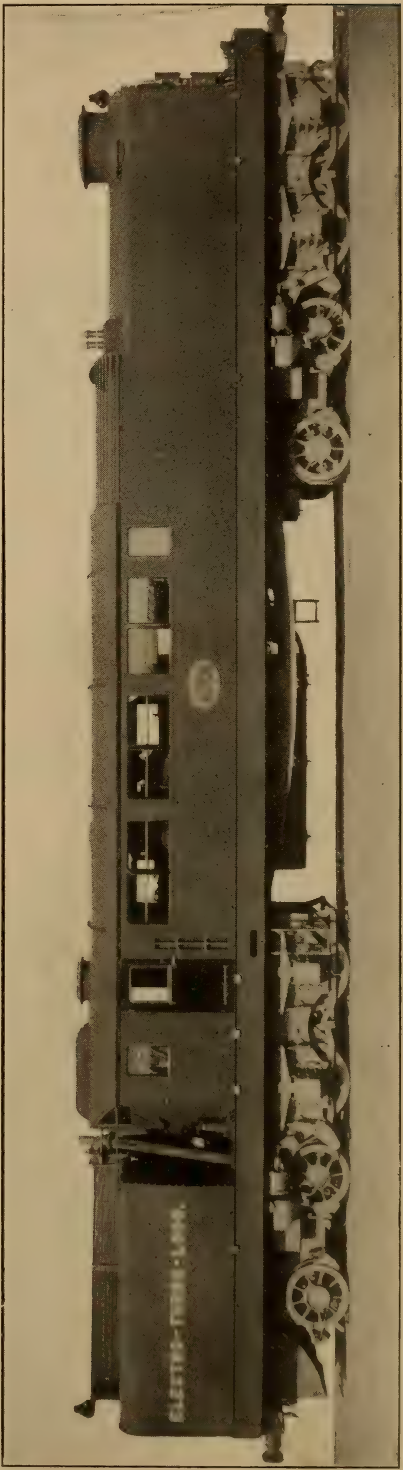


FIG. 1.—TURBINE ELECTRIC LOCOMOTIVE. NORTH BRITISH LOCOMOTIVE CO., LTD., GLASGOW

the armatures of which are built on the four main or driving axles of the locomotive. The exhaust steam from the turbine passes into an ejector condenser, and is, together with the circulating condensing water, delivered eventually to the hot well. As the steam turbine, unlike the reciprocating steam engine, requires no internal lubrication, the water of condensation is free from oil, and, consequently, is returned from the hot well direct to the boiler by means of a feed pump. The water evaporated by the boiler is, therefore, returned to the boiler again and again, and the supply of water carried in the tanks is actually circulating water for condensation purposes. This condensing water is circulated within practically a closed cycle by means of small centrifugal pumps driven by auxiliary steam turbines placed alongside the main turbine and dynamo. The cycle of the condensing water is from the tanks through the first pump, then through the condenser, where it becomes heated in condensing the exhaust steam, then to the hot well. From the hot well it passes through the second pump to the cooler, situated in front of the locomotive, where the full benefit of the blast of air caused by the movement of the locomotive, aided by a fan, is utilized for cooling the hot circulating water. After passing through the cooler the water is returned to the supply tanks ready for further condensation duties.

Owing to the fact that the condensation of the exhaust steam deprives the locomotive boiler of the usual exhaust blast which induces the draught through the firebox and boiler tubes, forced draught is provided by means of a small turbine-driven fan. The fan is placed within the cooler so that it will deliver hot air to the boiler fire and at the same

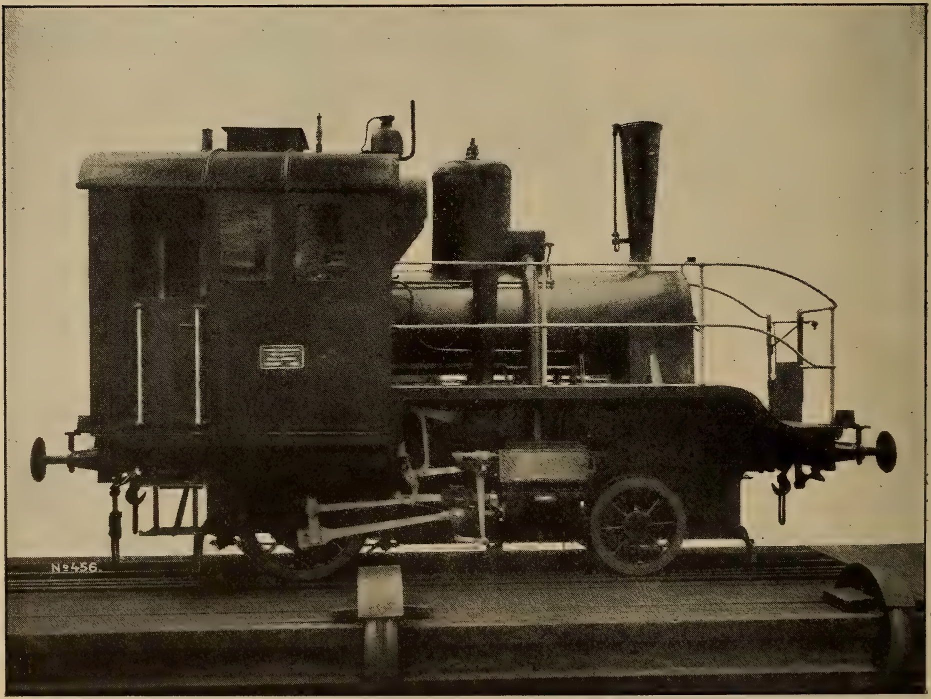


FIG. 2.—SMALL TANK ENGINE FOR HAULAGE OF LIGHT TRAINS. VALVE GEAR, LENTZ TYPE. HANOVER ENGINEERING WORKS, LINDEN-HANOVER

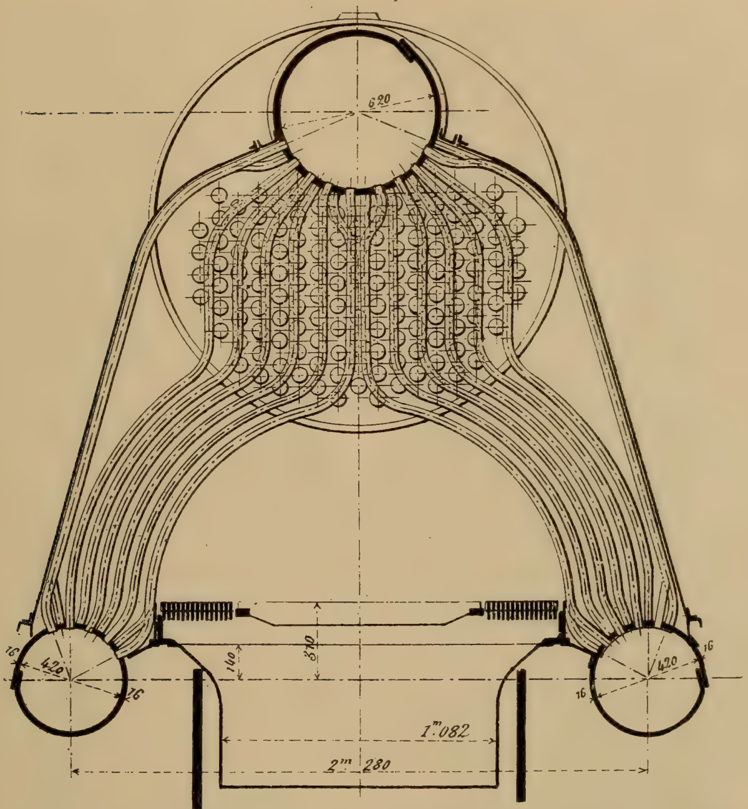


FIG. 3.—CROSS-SECTION OF WATER-TUBE FIREBOX IN USE ON 4-4-2 EXPRESS LOCOMOTIVES. NORTHERN RAILWAY OF FRANCE

time assist the current of air through the cooler. The small switchboard and the instruments required, the controller for grouping the four motors in series, series-parallel and parallel, according to the drawbar pull to be exerted, and the regulator for controlling the voltage in the electrical circuit, and, consequently, the speed of the train, are all placed on the driver's platform within easy reach.

The foregoing comprises the main and auxiliary machinery of this experimental locomotive. The whole is mounted upon a strong underframe, which is carried upon two eight-wheeled compound bogies, so constructed that they will easily negotiate curves. Each bogie carries two of the four driving motors already referred to.

So far, the engine is purely experimental, although it has been tested to some extent on certain Scottish railways; but the design presents strong possibilities, and it is probable that, notwithstanding the necessarily high initial cost, it will lead to notable developments in the future.

The small tank engine illustrated in Fig. 2 is intended for the haulage of light trains of two or three coaches, as used in rail-motor car traffic on branches or on main lines where stopping trains are few and the traffic small. Being constructed as a separate machine, the engine is adaptable for use for miscellaneous purposes more freely than a rail-motor car consisting of engine and coach permanently connected; but as the work required is of a light character, small dimensions and single driving wheels are quite sufficient.

Only one man is employed on the engine, and, to avoid the necessity for frequent firing, the boiler is of large capacity in proportion to the dimensions of the engine, and the location of all handles and fittings is chosen with a view to convenient operation. The boiler has a large dome, containing a water separator, but the cylinders are small (only 9 inches in diameter) and the steam pressure extremely high, being no less than 285 pounds per square inch. In fact, these little engines probably use the highest steam pressure at present to be found in the world's locomotive practice. The valve gear is of the Lentz type, employing poppet valves for admission and exhaust. It may be mentioned that, so far, sixty locomotives of various classes have been fitted with Lentz valves. The maximum speed required with these small engines is about 35 miles per hour, but this they will maintain easily; and in special trials, both independently and in comparison with other engines, the work has been done both efficiently and with economy. The builders are of the well-known Hanover Engineering Works, of Linden-Hanover, and they are responsible for design as well as construction.

Towards the end of 1909 the engineers of the Northern Railway of France rebuilt one of the 4-4-2 express locomotives with a new boiler having a water-tube firebox of special design. In its new form this engine has the 4-4-4 wheel arrangement, and practically forms a new design. During 1910 it was severely tested on the hardest trains included in the time-tables of the railway, and was then sent to the Brussels Exhibition, where it attracted considerable notice. The barrel of the boiler is constructed as usual. The upper part of the firebox consists of a cylindrical drum opening at one end into the barrel, and from this extend through the space of the firebox several sets of water-tubes, appropriately curved,

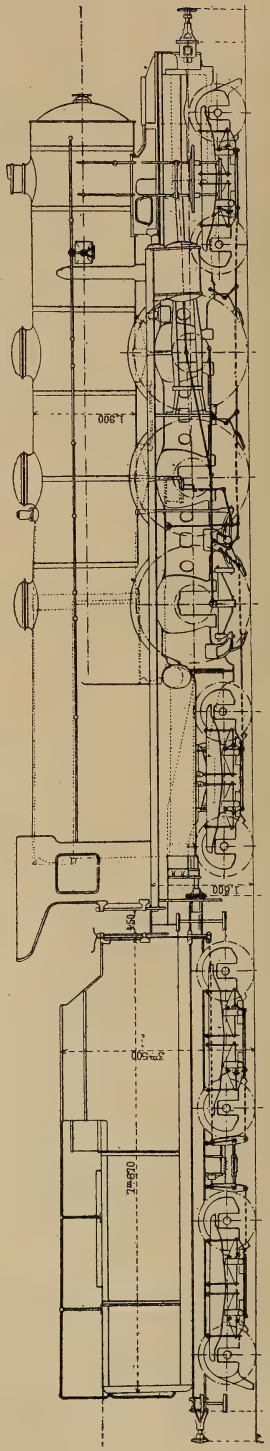


FIG. 4.—LINE DIAGRAM OF DEVELOPMENT OF WATER-TUBE FIREBOX DESIGN, AND A NEW WHEEL TYPE "BALTIC." NORTHERN FRANCE RAILWAY COMPANY

to smaller water drums on either side of the fire grate. A cross-section is shown in Fig. 3 which indicates the general features of the design. The steam pressure is unusually high, being 256 pounds per square inch.

A development of this design, introducing incidentally a new wheel type (4-6-4), named in some quarters the "Baltic" type, is under construction, and a line diagram of this is shown in Fig. 4. There are two engines of this class, one fitted with ordinary firebox and the other with a water-tube firebox similar to that of No. 2,741. Owing to the large diameters of the inside low-pressure cylinders, one is located in advance of the other.

The next novelty to be referred to is the flexible boiler, and it is almost needless to say that this has been introduced in American practice, the railway concerned being the Atchison, Topeka & Santa Fé, the scene of so many notable locomotive developments. On this railway remarkable articulated locomotives are in use of the 4-4-6-2 and 2-8-8-2 types, the latter being the present largest engines in the world; but apparently some difficulty has been experienced with these enormous machines in providing for sufficient flexibility on curves, owing to the great length of the boiler, hitherto rigid. Two engines have been constructed by the Baldwin Works, of Philadelphia, both having flexible boilers, but differing as regards the way in which the flexible connection of the two parts of the boiler is effected. In each case the boiler is in two sections, but one engine has a ball-and-socket connection between them, while the other, illustrated in Fig. 5, has a device of accordion character adapted to close in on one side and open out on the other on severe curves. Each section of the boiler is separate, so that the intermediate flexible chamber is not subjected to steam pressure, and therefore constitutes a combustion chamber. The furnace gases pass from one section to the other

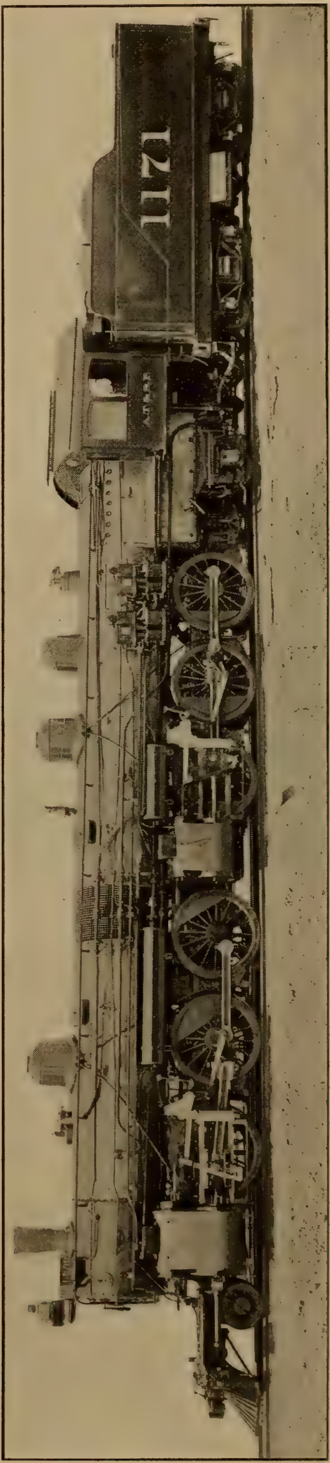


FIG. 5.—ENGINE WITH FLEXIBLE BOILER. BALDWIN WORKS, PHILADELPHIA, PA.

through a large cylindrical flue, so that cinders and ashes cannot lodge in the flexible connections. After passing through one set of boiler tubes the furnace gases traverse the tubes of a superheater of the Jacobs type. Then they pass through the intermediate chamber to a reheater for the low-pressure steam and thence to the tubes of the front boiler. In other respects the engine corresponds generally with American practice for large articulated locomotives of the Mallet type.

Before dealing with more ordinary developments and with novelties of a "local" character—that is, novel to particular railways or countries, but not generally—one other articulated design may be referred to here, though the initial engine of the class was constructed in 1909. This is the "Garrett" locomotive, introduced by Messrs. Beyer, Peacock & Co., Ltd., of Gorton Foundry, Manchester. The idea of this engine is to enable a boiler to be used much larger than the usual articulated designs will permit; and the desired result is attained by carrying the boiler on a frame that, as it were, bridges the space between the two engine trucks, so that it is quite clear of wheels and mechanism. The design is particularly suitable for narrow-gauge lines, and the dimensions of the engines so far built are small; but it is worthy of note that the engine illustrated by Fig. 6 has a boiler 3 feet 10⅞ inches in diameter, although its centre line is only 4 feet 6 inches above rail level. Owing to the long wheelbase, 24 feet 6 inches on this engine, though the wheelbase of each section is only 4 feet 3 inches, the engine can traverse curves more severe than is possible with other designs; but this fact also entails provision for vertical as well as longitudinal flexibility.

To provide for this the front truck carries its end of the boiler frame by means of a ball-and-socket connection, so that it can take up an inclined position on a curve when necessary; but the rear truck has a simple pivot connection, together with side supports and bearing surfaces, the ball-and-socket arrangement not being necessary at both ends.

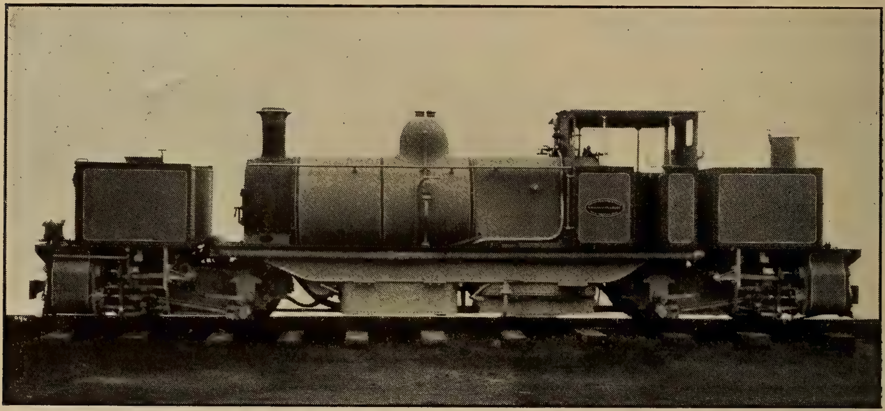


FIG. 6.—GARRETT LOCOMOTIVE. MESSRS. BEYER, PEACOCK & CO., LTD. GORTON FOUNDRY, MANCHESTER

The engine illustrated has been supplied for the Darjeeling-Himalaya Railway or 2-foot gauge. The first engine of this class was constructed for the Tasmanian Railways, and four others are now under construction. They will be fitted with Schmidt superheaters.

It will now be desirable to deal with other designs to be noticed in classes, and those with single driving wheels will first receive attention.

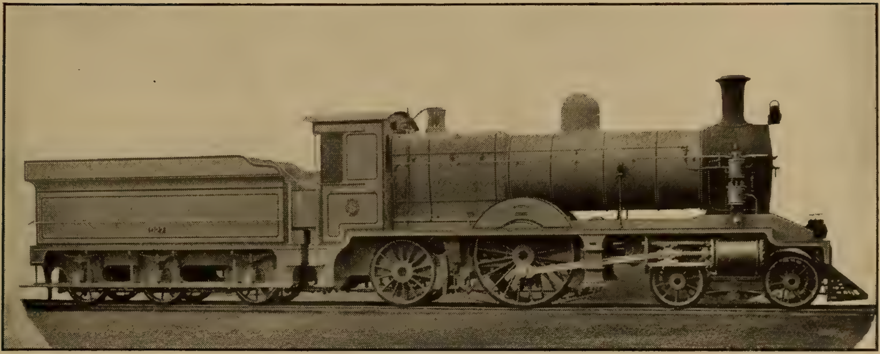


FIG. 7.—SINGLE-DRIVER LOCOMOTIVE WITH FIREBOX OF THE BELPAIRE TYPE. MESSRS. KERR, STUART & CO., LTD.

For about ten years no single-driver locomotives, except a few small tank engines for rail-motor or like traffic, have been constructed, so far as the writer is aware, in any country; and for practical purposes the "single" engine may be said to have disappeared, although it must be remembered that in England, at any rate, there are large numbers of such engines still doing good service, in some cases on really hard duties. Therefore, the construction in 1910 of four single-driver locomotives in conformity with the most advanced principles of locomotive design is a matter of more than passing interest.

The builders are Messrs. Kerr, Stuart & Co., Ltd., and the engines have been supplied to the order of the consulting engineer of the Shanghai-Nanking Railway; but in their construction something like a record was achieved by the builders, the first engine being ready for testing in steam within forty-seven days of the receipt of the order, while the others were only a few days behind.

At first inspection, one obtains from Fig. 7 the idea that these locomotives are of moderate size, with comparatively small driving wheels; but actually they are large, as will be appreciated when it is explained that the driving wheels have a diameter of 7 feet. The firebox is of the Belpaire type.

It will be noticed, also, that the small tank engine illustrated in Fig. 2 and already described belongs to the "single-driver" class.

In the four-coupled class British practice calls for most attention; but, as will be seen, the practice of other countries is not altogether devoid of interest in this connection.

In a large measure the 4-4-0 locomotive is going out of use, except

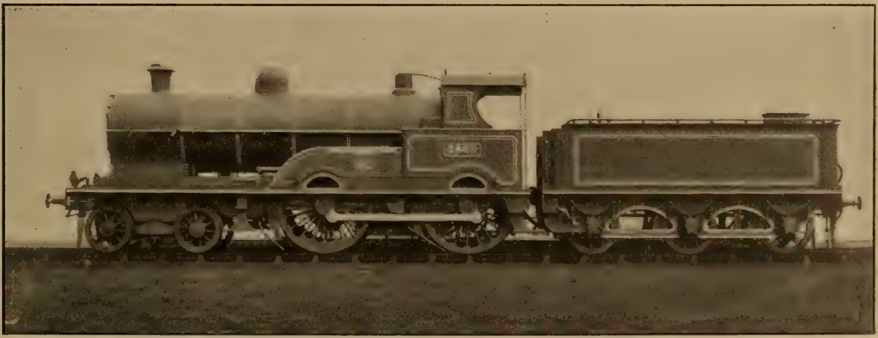


FIG. 8.—SMALL TANK ENGINE OF THE LONDON & NORTH WESTERN RAILWAY, ENGLAND. MESSRS. KERR. STUART & CO., LTD.

for lighter requirements, but that does not mean that it is disappearing from modern practice. In fact, many engines of this class have been constructed during recent years, principally, but not entirely, in Great Britain and Ireland, and some of these are notable in various ways.

About the middle of 1910 Mr. C. J. Bowen Cooke, chief mechanical engineer London & North Western Railway, constructed two 4-4-0 express locomotives for comparative trial, one having a Schmidt superheater, while the other was fitted with a feed-water heater. Both have given splendid results on peculiarly hard duties, and further engines of each series have been since constructed; but the honours rest with the superheater class, and particularly with the pioneer engine, No. 2,663, "George the Fifth." This engine, shown in Fig. 8, has dealt with maximum loads—that is to say, about 400 tons—on the hardest trains the North Western schedules include, in a way that has been unknown before, and on a very moderate coal consumption; and it is worthy of note that the London & North Western Railway contemplates fitting a hundred express goods and tank locomotives with the Schmidt superheater, mainly in consequence of the work done by this engine, while in the future, no doubt, the programme will be extended.

In general features the design is a development of the standard "Precursor" class designed by the late Mr. G. Whale; but it also includes many features which constitute it a new design. The superheater engines have 20-inch cylinders and 175 pounds of steam, whereas the Queen Mary class, with feed-water heaters, have 19-inch cylinders and 185 pounds pressure.

On the Caledonian Railway, too, the existing standard 4-4-0 express locomotive class has been improved by the addition of a Schmidt superheater, and No. 139 has given such good results that further superheater engines are under construction. The North Staffordshire Railway is one that, so far, has not possessed any really large express locomotives of the 4-4-0 type, for the reason that most of its requirements for fast traffic are of a moderate character; but during the last few years the requirements have become more severe, and, therefore, last year Mr. J. H. Adams introduced a new design of this type that represents a considerable advance upon previous practice.

Although the 4-4-0 type is now mainly used in the British Isles, several interesting locomotives of that class have been constructed for use in other countries, and an example thereof, as built by a German firm for use in South America, is notable because of the employment of inside cylinders. The railway concerned is the Rosario & Puerto-Belgrano, in the Argentine Republic, and the engines have been constructed by the well-known Berliner Maschinenbau A-G. The general type is that known as the "Outrance" of the French Northern Railway, but with inside cylinders. The capability required was to be able to haul from 300 to 320 tons at speeds of from 30 to 40 miles per hour up continued grades of 1 in 166, or loads of 350 tons at 50 to 55 miles per hour over gradients of 1 in 285. The design had to conform to the requirements of the Argentine railways, but otherwise the builders were allowed to follow the standards adopted by the Prussian State Railways. A Schmidt superheater is provided, and Schmidt piston valves are used, actuated by Walschaert valve gear.

It is now necessary to deal with the "Atlantic" type, though to some extent this is going out of use in favor of the 4-6-0 type, in view of the greater power capacity that the latter affords. Still, however, when the main requirement is boiler power, and with four-coupled wheels and a big boiler all demands can be complied with, there is yet a good field

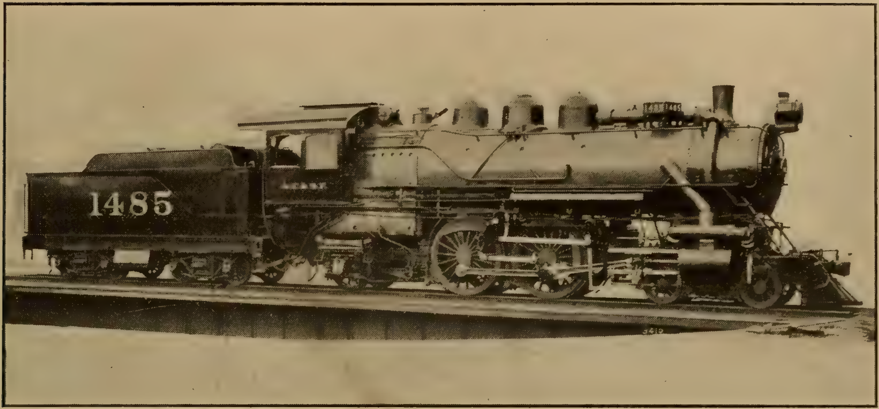


FIG. 9.—"ATLANTIC" TYPE ENGINE, ATCHISON, TOPEKA & SANTA FÉ RAILWAY. BALDWIN LOCOMOTIVE WORKS

for the Atlantic type, and, therefore, 4-4-2 locomotives will undoubtedly remain in use for a long period yet.

In Great Britain 4-4-2 locomotives still remain standard on several lines, the Great Northern, Great Central, North Eastern and North British in particular. On the Great Northern Mr. Ivatt's standard 4-4-2 express locomotives have been developed by the employment of Schmidt superheaters, larger cylinders and lower pressures, the result being a decided amplification of power capability.

On the North Eastern Railway a new series of 4-4-2 express engines is under construction which will have three high-pressure cylinders and a Schmidt superheater.

A few years ago an interesting series of "Atlantic" engines, compounded with four cylinders, was introduced on the Danish State Railways, designed by Mr. O. Busse, and an engine of the improved class constructed by the Berliner Maschinenbau A-G was exhibited at the Brussels Exhibiton last year. The four cylinders are placed together, a single piston valve controlling the steam distribution of each related pair of cylinders; but the high-pressure cylinders drive one pair of coupled wheels and the low-pressure cylinders the other pair. The firebox is of wide type, overhanging the frames, which are of bar construction. The trailing wheels of the engine have limited lateral play. The tender is also of special design, having four axles not arranged in bogies, the first and third being movable to some extent. The boiler is constructed in two rings, the first being parallel, while the second is slightly tapered.

Although locomotives of the 4-4-2 type and with four compound cylinders have, to some extent, gone out of favour in American practice in consequence of the employment of larger engines, generally non-compound, there is still a good deal of work for engines of the "Atlantic" type for dealing with requirements that would now be reckoned as of a more ordinary or moderate character; and the locomotive illustrated in Fig. 9 is a good example of the latest practice for such requirements. The design in question also comprises a number of features of interest.

The engine is a four-cylinder, balanced Vauclain compound, all cylinders driving the leading coupled wheels, and piston valves operated by the Walschaert valve gear are employed. The arrangement of the motion is unusual, for it will be noticed that, while the crosshead links are arranged in the ordinary manner, the curved link is placed well back, and

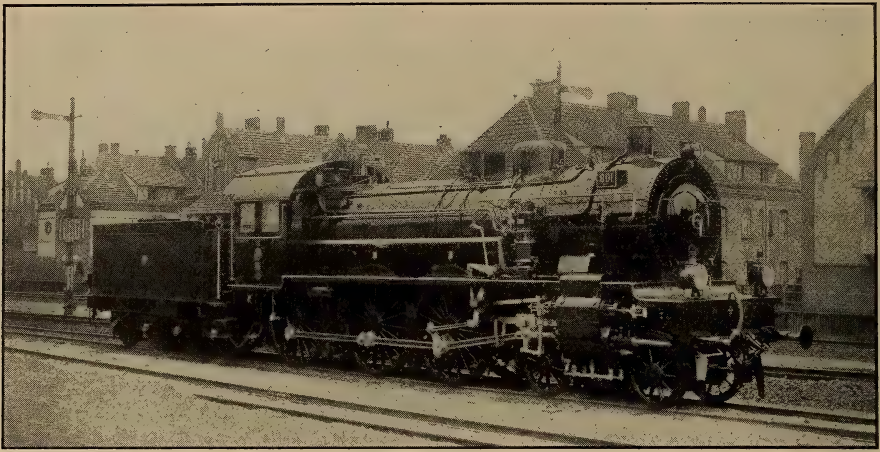


FIG. 10.—EXPRESS LOCOMOTIVE, PRUSSIAN STATE RAILWAYS. BERLIN ENGINEERING COMPANY

is operated from the return crank by a rod extending backward instead of forward, as usual.

The firebox is steel, stayed on the Jacobs-Shupert system, and oil fuel is used. The smokebox contains a Santa Fé reheater. The steam pipe from the dome is carried outside the boiler and divides to each high-pressure cylinder. The exhaust from these cylinders passes to the reheater and thence to the low-pressure cylinders.

The 4-6-0 wheel type is still in very general use, and in many quarters constitutes the principal express class for heavy traffic. On the Great Western Railway of England are, for example, engines having four high-pressure cylinders, a Swindon superheater, a taper or conical boiler, a huge Belpaire firebox, and the high steam pressure of 225 pounds per square inch, and have to conduct what are probably the most remarkable train services in the world. The

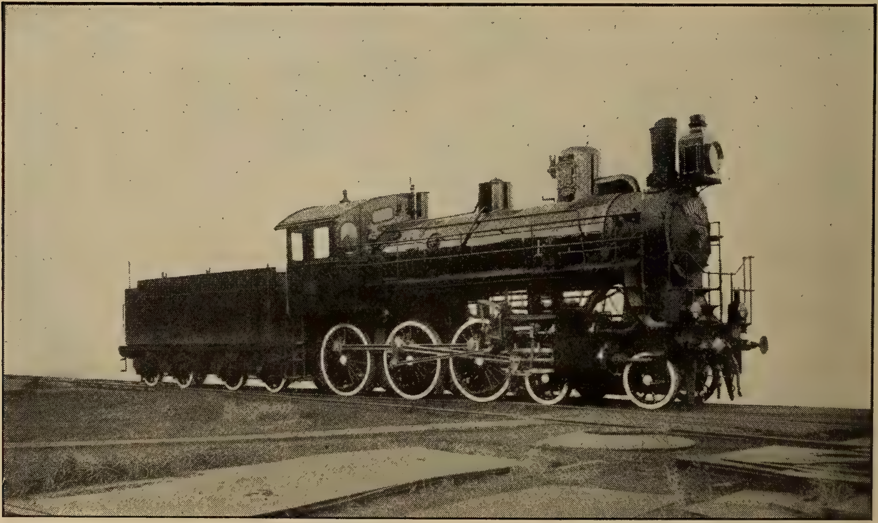


FIG. 11.—NON-COMPOUND PASSENGER ENGINE, OF MODERN PRACTICE IN RUSSIA. KOLOMNA ENGINEERING COMPANY

loads range up to 400 tons in the summer, but they have to cover 117½ or 118½ miles in 120 minutes, 173¾ miles in 180 minutes, and 225¾ miles in 247 minutes, the last mentioned including 30 miles of terrific gradients, while other sections are by no means easy, though possibly not particularly severe.

For several years a remarkable class of 4-6-0 express locomotives fitted with Schmidt superheaters have been in service on the Prussian State Railways; but in order to comply with still more exacting requirements the design has been developed by the Berliner Maschinenbau A-G, with four high-pressure cylinders, and one of these interesting locomotives is shown in Fig. 10. Originally, two of these engines were constructed, one being exhibited at the Brussels Exhibition, while the other was severely tested in regular service. The results given have been so satisfactory that we understand the builders have received an order for ten further engines of the same class, with a few detail alterations suggested by experience.

The four cylinders all drive the leading coupled axle, and each is provided with its own piston valve, the inside valves being actuated through levers from the outside valve gear, which operates the valve of the adjacent outside cylinders. The boiler is of the usual standard type for large Prussian engines, with a Schmidt superheater and a Marcotty smoke-consuming device. A special design of blast pipe is fitted whereby the orifice of the blast pipe is closed by a flap when steam is cut off, thus preventing air from being drawn into the cylinders. The regulator is also of a special type, Schmidt and Wagner patent, the valve being operated by a small steam motor instead of directly, as usual. In fact, the engine is provided with quite a number of special devices and conveniences too numerous to describe except with the aid of detailed drawings.

An interesting 4-6-0 design has been constructed by the Hanover Maschinenbau A-G for the Northern Railway of Spain. The design is a development of earlier practice, but is interesting in several ways. It is fitted with a Schmidt superheater, and is adapted for a moderate steam pressure. It is non-compound, and a Belpaire firebox is fitted.

The engine illustrated in Fig. 11 possesses considerable interest, owing to the fact that it represents an example of modern practice in Russia,

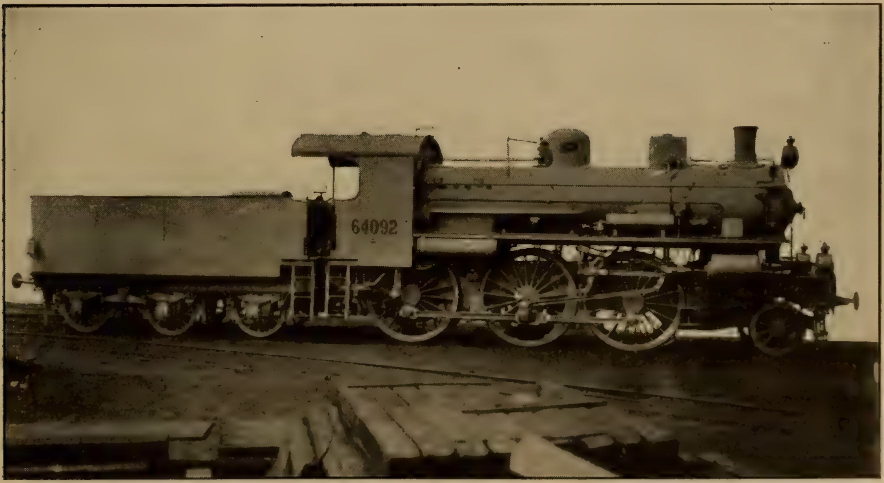


FIG. 12.—ENGINE OF 2-6-0 TYPE, ITALIAN RAILWAYS. ERNESTO BREDA, MILAN

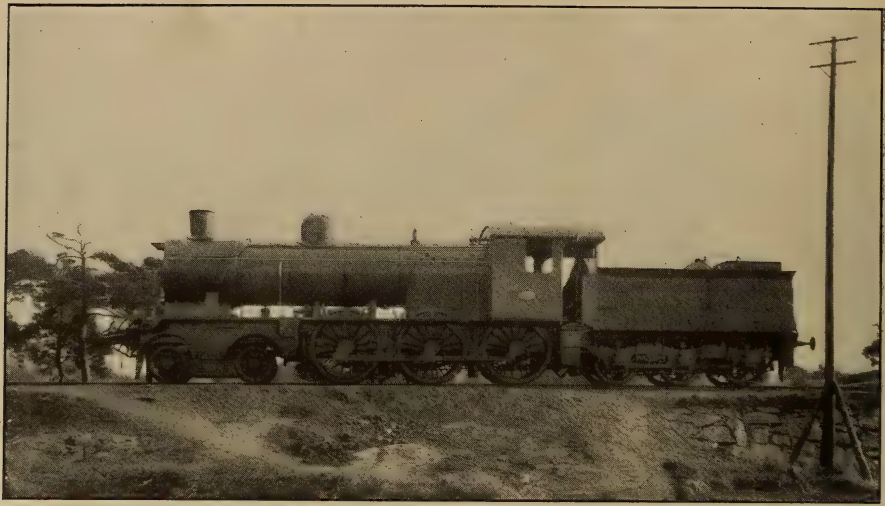


FIG. 13.—ENGINE WITH SCHMIDT SUPERHEATER, VALVE GEAR OF DEELEY DESIGN. NYDQUIST & HOLM, SWEDEN

about which comparatively little is generally known. It has been constructed by the Kolomna Engineering Company, and is one of a series of non-compound passenger engines fitted with the Schmidt superheater recently placed in service.

The extension of the front end over the bogie gives the engine a curious appearance. The cab is of large size, and some of the engines have a second cab on a six-wheeled tender, instead of the bogie tender shown, to provide protection during severe weather. The coupled axles are equalized together. The particular engine shown is the four thousandth built by this firm, this fact being specially indicated.

In Fig. 12 is shown an interesting 2-6-0 engine of a class that has recently been adopted, to some extent, by the Italian Railways, the builders in this particular case being the well-known firm of Ernesto Breda, of Milan. The design is similar to a compound class already in service, working with steam at 235 lbs, per sq. in., but is not compound, being fitted instead with a Schmidt superheater, the steam pressure being only 170 pounds. The cylinders are placed inside the frames, the large piston valves employed being arranged outside, and this fact gives the engine a somewhat peculiar appearance. This engine also was shown at the Brussels Exhibition.

The locomotive shown in Fig. 13 is interesting as an example of the influence of British methods upon Swedish practice, the cylinders and all the mechanism being inside the frames. The railway is the Stockholm - Westeras - Bergslagen. The Schmidt superheater is fitted, and the valve gear is of the Deeley design, in which all movements are taken from the crossheads.

During the last few years the "Pacific" type has become more and more standard, and, therefore, further designs can be referred to. One of the most interesting is provided by a class of 4-6-2 engines introduced on the Paris-Lyons-Mediterranean Railway. Two experimental locomotives were constructed at the railway works, one having four simple cylinders, the other being a four-cylinder compound equipped with the Schmidt superheater. The simple engine has a Schmidt superheater, and works with steam at 171 pounds, whereas the pressure of the compound is 227 pounds. It is understood that the former engine has given the most satisfactory results.

A number of 4-6-2 engines have been constructed by the Société Alsacienne de Constructions Mecaniques for the Midi & Paris-Orleans Railways of France, which provide good examples of the practice of these and other French railways. In many cases the 4-6-2 type is adopted to meet demands for great power in passenger service as distinct from power capability; but the engines referred to have fairly large coupled wheels, and are intended to haul express trains that are both heavy and fast. Here also the Schmidt superheater is used, in combination with the de Glehn compound system. A special design of firebox, first introduced about four years ago, is employed.

During the last few years 4-6-2 engines have been adopted so extensively on American lines that they hardly call for special reference; but the locomotive illustrated in Fig. 14, constructed by the American Locomotive Company, provides an interesting example of what has been done recently.

Prior to the advent of these engines the Vandalia was one of the few important roads in the country on which the Pacific type locomotive had not been adopted for at least the most difficult passenger service. In fact, because of the favourable service conditions on this line the lighter classes of motor power have been able to fully meet the requirements of both their freight and passenger traffic.

Although the design incorporates no new or unusual features, it is an excellent example of straightforward, well-proportioned design carefully worked out to meet the particular conditions of service for which the engines were intended. As far as the cylinder and running gear are concerned, it is practically identical with the engines of the same type built by the American Locomotive Company for the Pennsylvania Rail-

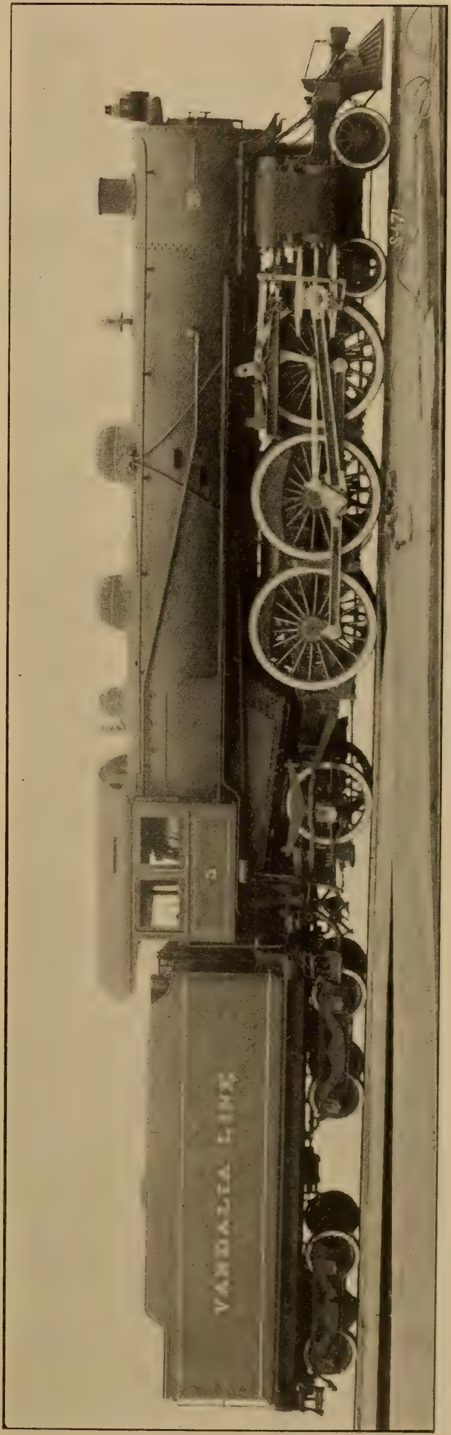


FIG. 14.—PACIFIC TYPE LOCOMOTIVE FOR THE VANDALIA LINE. THE AMERICAN LOCOMOTIVE COMPANY

road Company. The principal difference between the two designs are a reduction of the boiler pressure of from 210 to 220 pounds and the use of a smaller boiler and firebox, the boiler of the Vandalia locomotives being 76½ inches in diameter outside at the first ring, while the dimension in the Pennsylvania locomotives is 79¾ inches. The boilers of both locomotives are of the straight top type, and the tubes in each case are 21 feet long.

In line diagram Fig. 15 illustrates one of the latest engines constructed by the firm of J. A. Maffei, of Munich, for the Baden State Railways. A Schmidt superheater is employed, and the four cylinders work compound. As the design is fairly well known, further reference is not necessary.

During 1910 a remarkable class of 4-6-2 locomotives with Schmidt superheaters and four non-compound cylinders were placed in service on the Belgian State Railways. The class is not illustrated here, but the design possesses many features of interest, and the dimensions are included, together with those of a corresponding 2-10-0 class, in the table which concludes this article.

Hitherto the 4-6-2 wheel tank engine type has been quite ignored for main railway work in Great Britain, though it is to be found on a few narrow-gauge lines in Ireland. Therefore, the almost simultaneous adoption of this type by no fewer than four leading English railways is a matter of more than passing interest, especially as all the designs concerned are also remarkable in other ways.

The first engines of this type, as seen in Fig. 16, appeared on the North Eastern Railway towards the end of last year, and the design is the first for which Mr. Vincent L. Raven, the new chief machanical engineer, is responsible. In some respects the design is derived from Mr. Worsdell's three-cylinder 4-8-0 engines, introduced in 1909 for service

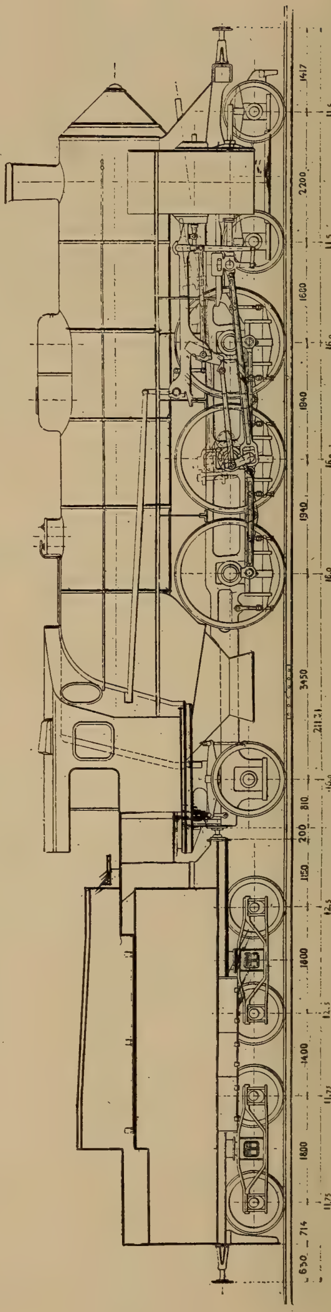


FIG. 15.—RECENT TYPE OF LOCOMOTIVE, BADEN STATE RAILWAY. J. A. MAFFEI, MUNICH

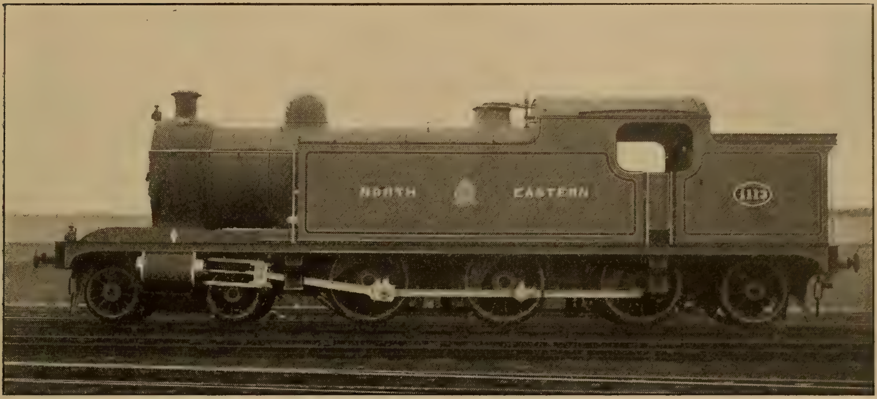


FIG. 16.—ENGINE (4-6-2 TYPE), NORTH EASTERN RAILWAY. MR. V. L. RAVEN

at gravitation sidings; but the new engines are intended for road traffic, mainly in connection with the heavy colliery business of the North Eastern Railway. There are three cylinders, all using high-pressure steam, and the cranks are 120 degrees apart, to provide for equable turning moment. Piston valves, operated by ordinary link motion, are fitted. The cab is roomy and comfortable, and the regulator handle and steam brake valve are so arranged as to be easily manipulated by the driver when he is engaged watching for hand signals from guards or shunters.

During the first weeks of this year the London & North Western and London, Brighton & South Coast Railways placed in service engines having this wheel arrangement, but the Great Central locomotives of this type are still under consideration. All three designs are intended for passenger traffic, and in some respects they are developments of 4-4-2 tank engine designs already in use, though with important modifica-

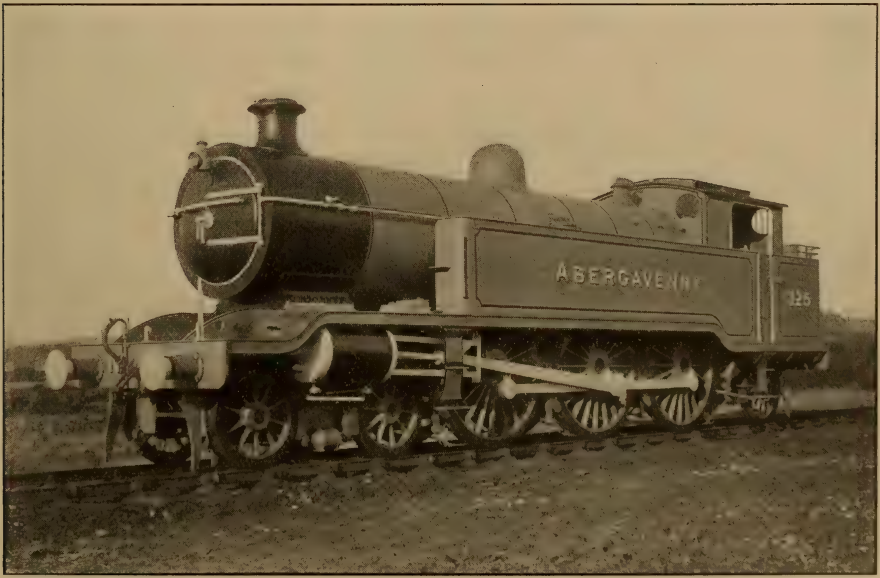


FIG. 17.—A "BRIGHTON" ENGINE IN SERVICE ON THE LONDON, BRIGHTON & SOUTH COAST RAILWAY

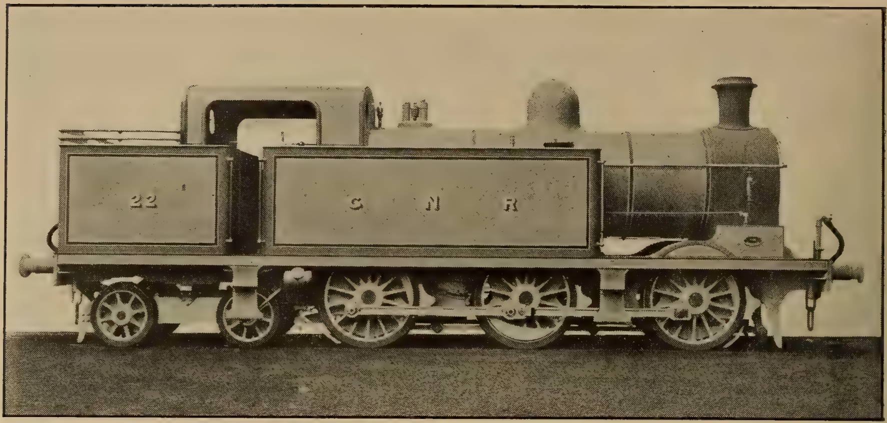


FIG. 18.—A MODERN EXAMPLE OF ENGINE EMPLOYED IN IRELAND (5-FOOT 3-INCH GAUGE). BEYER, PEACOCK & CO., LTD.

tions. The first of the "Brighton" engines is illustrated in Fig. 17. The new engine is intended for working the very heavy trains which some of the time-table duties entail, and in this respect should overcome the difficulties which occasionally occur when the 4-4-2 express tanks are overloaded, as sometimes happens, notwithstanding their splendid work with trains up to 300 tons, or a little over. The design includes the provision of a Schmidt superheater, thus according with the tendency of "Brighton" locomotive practice, and the steam pressure is only 160 pounds per square inch.

In the case of the L. & N. W. R. design, Mr. Bowen Cooke has not fitted the first engine with a superheater, but others of the series are to be equipped with the Schmidt apparatus, and Mr. Robinson is also employing this superheater for his engines.

Of late years many railways have introduced the 0-6-4 tank engine type, the trailing bogie being adopted for the purpose of supporting a large bunker; but, although the type was, it is believed, employed by an Irish railway—the Great Southern & Western Railway—upwards of thirty years ago, the locomotive shown in Fig. 18 is interesting as being the only modern example employed in Ireland for the standard (5-foot 3-inch) gauge.

They have been constructed for the Great Northern Railway of Ireland by Messrs. Beyer, Peacock & Co., Ltd., of Manchester, to the designs

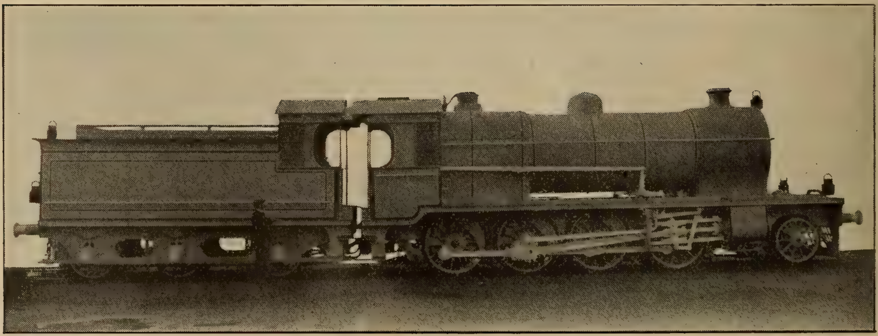


FIG. 19.—ENGINE FOR THE INDIAN STATE RAILWAYS. VULCAN FOUNDRY COMPANY

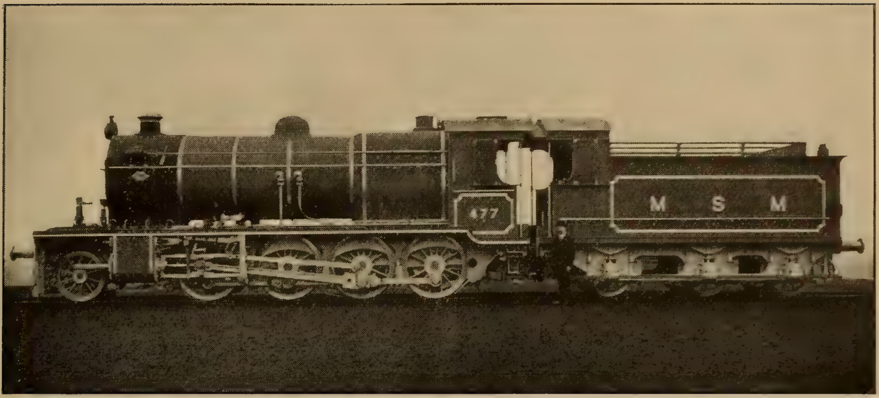


FIG. 20.—LOCOMOTIVE FOR THE MADRAS & SOUTHERN MAHRATTA RAILWAY, INDIA. R. STEPHENSON & CO., LTD., DARLINGTON

of Mr. Charles Clifford, the locomotive superintendent of the railway. They correspond, as regards main features, with the standard practice of the railway, and, as will be seen, there are features of resemblance to the locomotives of the English Great Northern Railway.

Eight-coupled locomotives are now so general for heavy freight service that examples of interesting practice are far too numerous to permit of reference to more than two or three of them.

The engine shown in Fig. 19 is one of a series constructed by the Vulcan Foundry Company, of Newton-le-Willows, for the North Western division of the Indian State Railways. In general features it accords with the standard practice of Indian railways, employing large boilers, with Belpaire fireboxes and Walschaert valve gear.

Another Indian locomotive is illustrated in Fig. 20, this being, it is believed, the first instance of the employment of the Schmidt superheater in Indian practice. The engine belongs to the Madras & Southern Mahratta Railway, and has been constructed by the well-known firm of Robert Stephenson & Co., Ltd., of Darlington. The design corresponds generally with the recommendations of the Indian Standards Committee,

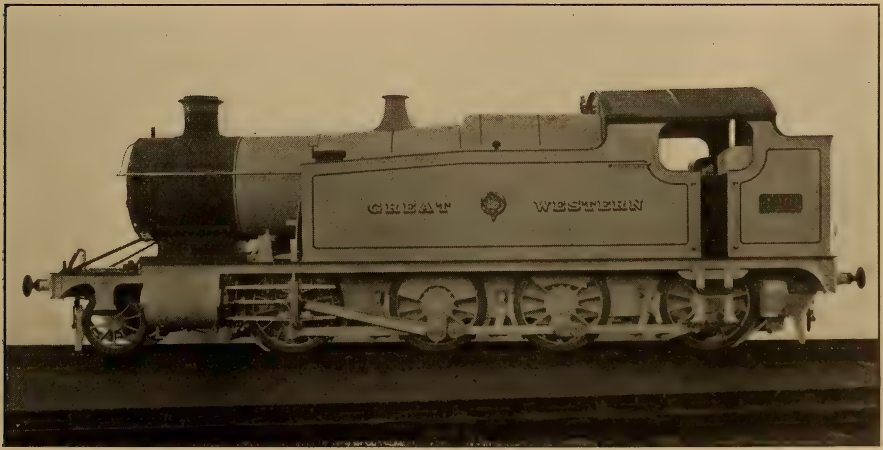


FIG. 21.—ENGINE OF THE 2-8-0 TYPE, GREAT WESTERN RAILWAY

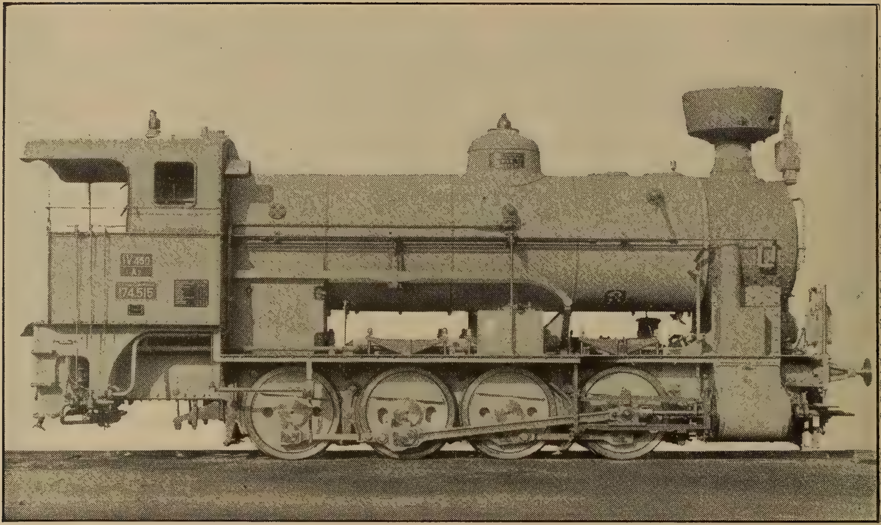


FIG. 22.—ENGINE OF THE 0-8-0 TYPE, BUILT BY THE VIENNA ENGINEERING COMPANY, FLORIDSDORF, FOR THE AUSTRIAN STATE RAILWAYS

modified as required by the fact that a superheater is fitted and as called for by the officers of the railway. The steam pressure is only 160 pounds per square inch, thus providing a further example of the tendency to lower steam pressures when using highly superheated steam.

Hitherto the 2-8-0 wheel type has been practically unknown in British locomotive practice for tank engines, and for that reason the new design illustrated in Fig. 21 is interesting; but there are also other features which render these engines notable. The design has been introduced for the purpose of dealing with the heavy South Wales mineral traffic of the Great Western Railway, and provides a tank-engine version of the eight-coupled (2-8-0) tender engines used for the main-line coal trains. Hitherto the local traffic has been dealt with by 2-6-2 tank engines, with the ordinary six-coupled saddle tanks for the lighter duties.

In most respects the new engines correspond with the "consolidation" tender engines, and they have the standard "coned" boiler, Belpaire fire-

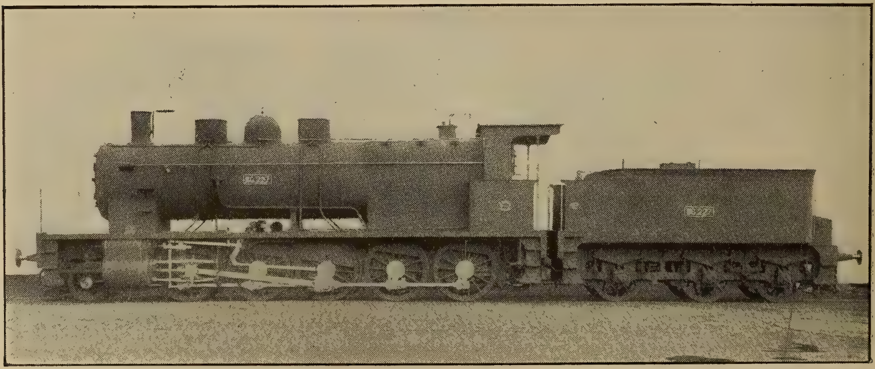


FIG. 23.—ENGINE FOR THE BONE-GUELMA RAILWAY, TUNIS, SOCIÉTÉ ALSACIENNE DE CONSTRUCTIONS MECANIQUES

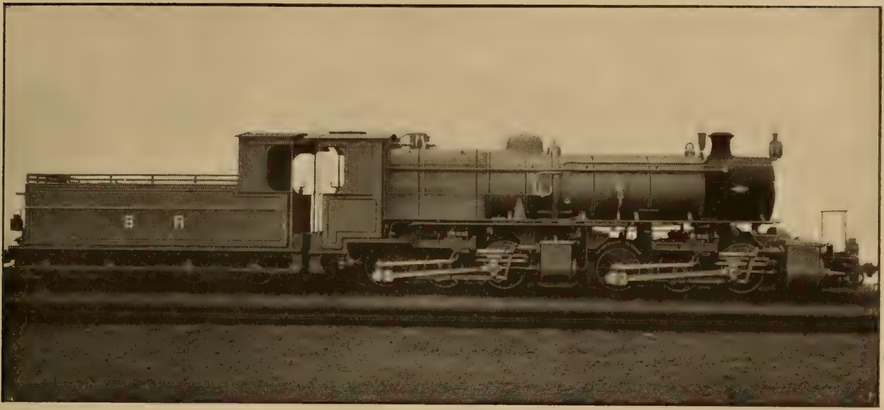


FIG. 24.—ENGINE, MALLET TYPE, FOR BURMA RAILWAYS. NORTH BRITISH LOCOMOTIVE COMPANY

box, outside cylinders with the unusual stroke of 30 inches, a leading pony truck, and wheels arranged as in the main line engines. They are also fitted with a Swindon superheater. To avoid the difficulty that the coupled wheelbase is 20 feet, the trailing wheels are arranged in sliding axle-boxes, and the coupling rods are fitted with spherical joints, so that considerable side-play is allowed for, notwithstanding the direct coupling. So far as the tank engine features are concerned, the engines are standard in many ways with the 2-6-2 tank engines.

Although the gauge of the South African Railways is only 3 feet 6 inches, a number of very large and remarkable locomotives are in use thereon, in order to cope with the heavy loads to be dealt with and the severe gradients to be negotiated. Hitherto, however, the tender engines of usual type with more than twelve wheels have been unknown, the modern types being 4-6-2 and 4-8-2 for heavy passenger and goods traffic, respectively. Consequently, the introduction of still larger machines with the 4-8-2 wheel arrangement is a matter of interest, more especially as that wheel type is almost, if not quite, unknown in the world's practice.

The new engines are intended for use on the Cape Government section of the South African Railways, and have been constructed by the North British Locomotive Company, Ltd., of Glasgow, to the designs of Mr. H. M. Beattie. They are amongst the largest engines yet built for the 3-foot 6-inch gauge. The cylinders have the large dimensions of 20½ inches diameter, with a stroke of 28 inches, and to supply them with steam a boiler of 5 feet 7¾ inches diameter

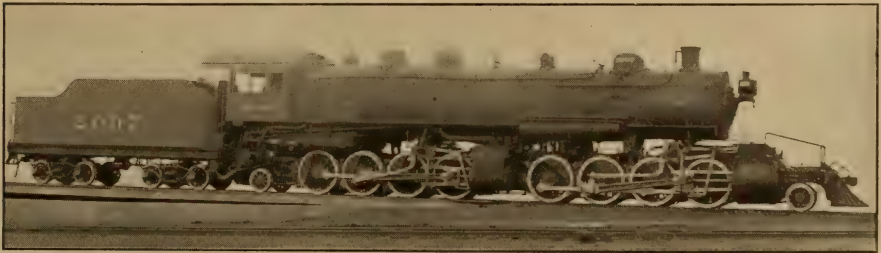


FIG. 25.—ENGINE OF ARTICULATED DESIGN, ST. LOUIS & SAN FRANCISCO RAILWAY. AMERICAN LOCOMOTIVE COMPANY

## DATA OF LOCOMOTIVES ILLUSTRATED AND DESCRIBED.

T—Tank Engine. C—Compound. S—Superheater Fitted. A—Articulated.

| Fig. | Railway. | Builder. | Gauge. | Type. |
|---|---|---|---|---|
| 1 | | North British Loco. Co., Ltd. | ..... | Turbo-electric S |
| 2 | | Hanover Engineering Co. | ..... | 2–2–0 T |
| 3 | Northern (France) | Railway Company | ..... | 4–4–4 C |
| 4 | Northern (France) | Railway Company | ..... | 4–6–4 C S |
| 5 | A. T. & S. F. (U. S. A.) | Baldwin Works | ..... | 2–6–6–2 C S A |
| 6 | Darjeeling Himalaya (India) | Beyer Peacock & Co., Ltd. | 2′ 0″ | 0–4–4–0 T A |
| 7 | Shanghai-Nanking (China) | Kerr Stuart & Co., Ltd. | ..... | 4–2–2 |
| 8 | London & North Western (Eng.) | Railway Company | ..... | 4–4–0 S |
| | Rosario & P. B. (Argentine) | Berlin Engineering Co. | 5′ 6″ | 4–4–0 S |
| | Great Northern (Eng.) | Railway Company | ..... | 4–4–2 S |
| | State Railways (Denmark) | Berlin Engineering Co. | ..... | 4–4–2 C |
| 9 | A. T. & S. F. (U. S. A.) | Baldwin Works | ..... | 4–4–2 C |
| | Great Western (Eng.) | Railway Company | ..... | 4–6–0 S |
| 10 | State Railways (Prussia) | Berlin Engineering Co. | ..... | 4–6–0 S |
| | Northern (Spain) | Hanover Engineering Co. | 5′ 6″ | 4–6–0 S |
| 11 | Russian State | Kolomna Engineering Co. | 5′ 6″ | 4–6–0 S |
| 12 | State (Italy) | Ernesto Breda | ..... | 2–6–0 S |
| 13 | Stockholm Westeras (Sweden) | Nydquist & Holm | ..... | 4–6–0 S |
| | P. L. M. (France) | Railway Company | ..... | 4–6–2 S |
| | P. L. M. (France) | Railway Company | ..... | 4–6–2 S |
| | Midi (France) | Société Alsacienne | ..... | 4–6–2 C S |
| 14 | Vandalia (U. S. A.) | American Locomotive Co. | ..... | 4–6–2 |
| 15 | Baden State | J. A. Maffei | ..... | 4–6–2 C S |
| | Belgian State | John Cockerill | ..... | 4–6–2 S |
| | Belgian State | Haine St. Pierre | ..... | 2–10–0 S |
| 16 | North Eastern (Eng.) | Railway Company | ..... | 4–6–2 T |
| 17 | L. B. & S. C. R. (Eng.) | Railway Company | ..... | 4–6–2 T S |
| 18 | Great Northern (Ireland) | Beyer Peacock & Co., Ltd. | 5′ 3″ | 0–6–4 T |
| 19 | North Western State (India) | Vulcan Foundry Co. | 5′ 6″ | 2–8–0 |
| 20 | Madras & S. M. (India) | R. Stephenson & Co., Ltd. | 5′ 6″ | 2–8–0 S |
| 21 | Great Western (Eng.) | Railway Company | ..... | 2–8–0 T S |
| | South African | North British Loco. Co., Ltd. | 3′ 6″ | 4–8–2 |
| 22 | Austrian State | Vienna Eng. Co. (Floridsdorf) | ..... | 0–8–0 |
| | Italian State | Ernesto Breda | ..... | 2–8–0 |
| 23 | Bone-Guelma (Tunis) | Société Alsacienne | ..... | 2–10–0 S |
| 24 | Burma | North British Loco. Co., Ltd. | Metre. | 0–6–6–0 A C |
| 25 | St. Louis & San Francisco (U.S.A.) | American Locomotive Co. | ..... | 2–8–8–2 A C |

and with a barrel length of 20 feet 2½ inches is provided. The boiler has an internal combustion chamber extending from the firebox 2 feet 2 inches into the barrel. Frames of bar type are employed, placed inside the wheels, except at the rear, where they are built up of plates, so as to enclose the firebox, which is of wide type, extending over the trailing wheels.

An interesting 0-8-0 engine, which Fig. 22 illustrates, is constructed by the Vienna Engineering Company, of Floridsdorf, for the Austrian State Railways for heavy freight traffic. The cylinders are non-compound. A steam drier is provided in the front section of the boiler; this consists of a steam chamber, through which pass tubes for the conveyance of the furnace gases from the boiler tubes

## DATA OF LOCOMOTIVES ILLUSTRATED AND DESCRIBED.

| Cylinders (Inches). | Coupler Wheels. | Steam Pressure. | Heating Surface (Square Feet). | Grate Area (Square Feet). | Weight in Working Order (Tons). | Fig. |
|---|---|---|---|---|---|---|
| 9 x 16 | 3′ 6″ | 285 | 202 | 4.3 | 21 | 1 |
| {13⅝<br>22⅝} x 25⅝ | 6′ 8″ | 256 | 3,412 | 37.8 | 76 | 2 |
| {17⅝} x 25⅝<br>{25} x 29¼ | 6′ 8″ | 227 | 3,885 | 44.5 | 102 | 3 |
| {24<br>38} x 28 | 5′ 9″ | 220 | 5,503 | 52.5 | 175 | 4 |
| 11 x 14 | 2′ 2″ | 160 | 667 | .... | 14¼ | 5 |
| 18 x 26 | 7′ 0″ | 180 | 1,650 | 28. | 56 | 6 |
| 20 x 26 | 6′ 9″ | 175 | 1,850 | 22.4 | 60 | 7 |
| 20 x 26 | 6′ 2″ | 170 | 1,704 | 24. | 49 | 8 |
| 20 x 24 | 6′ 8″ | 150 | 2,481 | 31. | 69½ | |
| {14½<br>24} x 26 | 6′ 6″ | 213 | 2,077 | 34.5 | 70 | |
| {15<br>25} x 26 | 6′ 1″ | 220 | 2,508 | 4.8 | 103 | 9 |
| 14½x 26 (4) | 6′ 8″ | 225 | 2,143 | 27.1 | 76 | |
| 16¾x 24¾ (4) | 6′ 6″ | 170 | 2,213 | 28. | 76 | 10 |
| 22 x 26 | 5′ 10″ | 170 | 2,235 | 28.9 | 64 | |
| 23 x 26 | 5′ 10″ | 170 | 1,773 | 29. | 71 | 11 |
| 21¼x 27½ | 6′ 1″ | 175 | 1,526 | 26.5 | 54¼ | 12 |
| 20½x 24 | 5′ 7″ | 170 | 1,376 | 25.8 | 55 | 13 |
| 18¾x 25⅝ (4) | 6′ 7″ | 171 | 3,040 | 45.7 | 93¼ | |
| {15¾<br>24½} x 25⅝ | 6′ 7″ | 227 | 3,044 | 45.7 | 92¾ | |
| {16<br>25} x 26 | 6′ 3″ | 227 | 3,013 | 43. | 81 | |
| 24 x 26 | 6′ 8″ | 200 | 4,389 | 56.5 | 114 | 14 |
| {16¾} x 24<br>{25⅝} x 26⅜ | 5′ 11″ | 227 | 2,246 | 48.4 | 87 | 15 |
| 19¾x 26 (4) | 6′ 6″ | 180 | 3,045 | 53.8 | 102 | |
| 19¾x 26 (4) | 4′ 9″ | 180 | 2,564 | 53.8 | 98½ | |
| 16½x 26 (3) | 4′ 7″ | 180 | 1,648 | 23. | 87½ | 16 |
| 21 x 26 | 6′ 7″ | 160 | ...... | .... | 86 | 17 |
| 17 x 24 | 4′ 3″ | 175 | 1,086 | 16.3 | 56 | 18 |
| 20 x 26 | 4′ 8½″ | 180 | 2,087 | 32. | 71¼ | 19 |
| 22 x 26 | 4′ 8½″ | 160 | 1,996 | 32 | 73½ | 20 |
| 18½x 26 | 4′ 7″ | 200 | 1,567 | 20.6 | 76 | 21 |
| 20½x 28 | 4′ 6″ | 180 | 2,317 | 37 | 82¼ | |
| 20 x 23 | 4′ 2″ | 160 | 1,980 | 27. | 55 | 22 |
| {19¼<br>29½} x 27⅝ | 4′ 6″ | 227 | 2,156 | 30.25 | 65 | |
| 24½x 26 | 4′ 7″ | 170 | 1,998 | 29. | 66 | 23 |
| {15½<br>24¼} x 20 | 3′ 3″ | 180 | 1,513 | 33. | 58¼ | 24 |
| {24½<br>39} x 30 | 4′ 9″ | 200 | 5,162 | 75.4 | 186 | 25 |

to the smokebox. A special spark arrester is fitted on the chimney.

So far as ten-coupled engines are concerned, various Continental firms have been responsible for many interesting designs; but as a number of these were illustrated in the Railway Number of Cassier's Magazine, only one design need be referred to here (Fig. 23). This is employed for engines conducted by the Société Alsacienne de Constructions Mecaniques for the Bone-Guelma Railway, of Tunis. Two ordinary cylinders are used, and a Schmidt superheater is fitted, but otherwise the design is very similar to that of 2-10-0 engines on various French railways.

In conclusion, it is necessary to refer to a few examples of articulated practice, in addition to those dealt with earlier, for special reasons.

For many years the Burma Railways have employed articulated engines, but hitherto these have been of the Fairlie type. In the latest engines supplied the Mallet type is adopted, and one of them, constructed by the North British Locomotive Company, is illustrated in Fig. 24. The gauge is 1 metre; but, owing to the severity of curves, it would be almost impossible to comply with requirements except by means of articulated engines.

The boiler is of a large size, fitted with a Belpaire firebox, and rests on three saddles or supports, the centre one sliding on a bronze liner, while the front one serves for controlling the sideway movements of the leading section of the engine frame on curves. In addition to steam brakes on the engine and vacuum brakes on the tender and for controlling the train, a Meyer counter-pressure brake is employed for use on long down-grades, and the muffler for this is seen on the boiler immediately behind the chimney.

Finally, an interesting articulated design recently constructed by the American Locomotive Company for the St. Louis & San Francisco Railway (Fig. 25) may be referred to.

The Mallet locomotives are intended for pusher service. They are designed to handle 1,950 tons on a 1 in 66 grade at a speed of 5 miles per hour and 1,600 tons on the same grade at 10 miles per hour.

The maximum grade on which they will operate is 1 in 47, expecting to haul 1,230 tons at a speed of 5 miles per hour or to make a speed of 10 miles per hour on the same grade with 1,000 tons. They are designed to pass through curves of a minimum of 10 degrees. Aside from the fact that they are the first locomotives of the 2-8-8-2 type of wheel arrangement constructed by this company, the most interesting feature of the design lies in the arrangement of steam pipes to the high-pressure cylinders. These pipes are in two sections, one being located inside of the boiler and connecting to a "T"-head, which, in turn, is connected to the throttle pipe. The application of this arrangement was possible because of the use of a combustion chamber in the boiler, which allows space between the tubes and the shell of the boiler for the introduction of the pipes. The outside section of the high-pressure steam pipe consists of a copper pipe fitted with an elbow at either end, and has a ball joint connection with the lower end of the inside pipe and also with the cylinders. The construction is such that the outside section can be removed without in any way disturbing the inside pipe.

This arrangement has several important advantages. It simplifies construction by obviating the necessity for using the special design of cast-steel dome employed in previous engines of the Mallet type, where the high-pressure steam pipes are on the outside of the boiler. Being located inside the boiler, the steam pipes do not in any way interfere with the engineer's view ahead. In cases where, because of the length and size of the boiler, the ordinary arrangement of outside steam pipes obstructs the outlook of the engineer, this arrangement, therefore, offers a satisfactory solution of the difficulty.

In addition to the foregoing, many other interesting engines could be referred to, but space will not permit. The writer is indebted to the various firms and railways mentioned for photographs and particulars of the engines illustrated and described, and their courtesy and assistance are hereby acknowledged.

# THE GREAT TRANSFORMATION

By **Henry Harrison Suplee**

## II.—THE TRANSFORMATION IN COMMERCE

"Soon shall thy arm, unconquered steam, afar
Drag the slow barge, or drive the rapid car;
Or on wide-waving wings expanded bear
The flying chariot through the fields of air.

"Fair crews triumphant, leaning from above,
Shall wave their fluttering kerchiefs as they move;
Or warrior bands alarm the gaping crowd,
And armies shrink beneath the shadowy cloud."
—Erasmus Darwin, Botanic Garden, Part I., Canto I., lines 289-296, 1791.

IN considering the changes which the general introduction of aerial navigation may be expected to make in the conduct of commercial affairs, it is desirable to examine in a preliminary fashion the influence which engineering developments have already had upon commerce.

In former ages commerce was carried on almost wholly by sea; the few merchants who ventured to guide their pack animals along the highway did so in fear and trembling, and the sum of their business was of comparatively small account. The caravans which crossed the desert and brought the rare products of the East to the Mediterranean ports were of more importance, and it was because of the desire to replace their slow and uncertain movements that Columbus sailed to the west and Vasco da Gama rounded the Cape. For long generations afterwards the great merchants of the world risked their fortunes in ventures sent out upon sailing ships in charge of trusted employees, looking forward through months and years of silence and expectation until their ships should come in, bringing them large profits on their investments. Those were the days when men bought cheap and sold dear, and made their fortunes largely from the ignorance of one part of the world about what the other part was doing.

Then came the steamship, the railway, the telegraph, the submarine cable, the long-distance telephone, and the secrets of commerce could no longer be hid from the layman; and to-day the great ocean carrier is available for transport, not for a game of hazard in which the chief elements are chance and ignorance, but for a fixed charge equivalent to the service rendered, at the risk of an insurance company. It is possible for old men to-day to remember when merchant voyages to the Far East were gamblers' risks, and when the railway from the Atlantic to the Pacific coasts of America was yet a thing to be accomplished.

The other day a self-confident Italian physicist succeeded in sending a message of three brief dots through space across the Atlantic, and his assertion was received with doubt. To-day the instruments of radio-telegraphy are commercially at work and no one even shrugs his shoulders.

Two years ago a venturesome French aviator leaped into space off the chalk cliffs at Sangatte, and in a few minutes descended in the shadow of Dover Castle, and his feat was acclaimed in Europe and America. In the short months which have elapsed the Channel has been repeatedly crossed through the air, and the front pages of the newspapers have remained undisturbed; the novelty has worn off, though the fact remains more important than ever. The most turbulent frontier which has separated opposing nations has been rendered grotesquely absurd.

It is not the intention here to consider how long a time may elapse before the Channel, the Alps, the Rhine, or the Himalayas may cease to appear as boundaries or local indications; these are matters of degree and not of kind. It will suffice to emphasize the fact that, in the air, there are no frontiers, and that where a single aeroplane has passed to-day a fleet of thousands may pass within ten years, carrying men and merchandise, with utter disregard of the marks and creatures thousands of feet below them upon the surface of the earth.

Leaving aside, then, the details of the aerial fleets which must surely supersede the feeble machines which are being used to-day, let us consider first what influence the freedom of the air may be expected to have upon the commerce of the early future.

Doubtless the most important fact which the delimitation of frontiers will produce at first will be the helplessness of customs officials. When ports may be ignored, inspections may be so readily evaded that the present methods of government to collect duties will surely need revision. When men come into a country, not upon the surface, but on any plane of their own selection, the ability to enforce a system of customs will become a curiously interesting problem. Apart from the ability to enter a country bearing rich and dutiable cargo at any chosen elevation above the surface, the aviator may also choose his general route, and select the bleak and uninhabited coasts of Labrador, or the dunes of the Carolinas, and keep well away from the route of the great metropolis in his flight over the border.

In like manner the point of landing may be selected at will and shifted among such an infinite variety of points that the computations of the theory of probabilities may well be invoked to guess at the places where people are receiving the things which they own.

It must not be inferred that the artificial crime of smuggling is intended to be encouraged; but it is

92474

extremely probable that, with the helplessness of the customs officials, due to the physical limitations of their activities, a revision of this method of regulating commercial affairs may be expected. There is no surer way of changing a custom than by rendering it ridiculous, and when officials find themselves laughed at it may reasonably be assumed that their occupation is of brief existence.

It may be safely assumed, then, that universal freedom of transport, regardless of local legislation and national boundaries, will mean universal freedom to commerce, giving to the trade between various countries all the opportunities which have shown themselves so advantageous between the various commonwealths constituting the United States of America.

Dismissing this point, therefore, we may proceed to consider the advantages which must follow the elimination of the terminal station, whether this be the dock warehouses which at present obstruct water transport or the railway stations which produce such centres of artificial congestion on land.

The introduction of railways provided greatly increased speed for the hauling of merchandise over long distances, but at the same time removed a very great advantage possessed by the old-time carrier's cart. It is most desirable to be able to convey goods for hundreds of miles at high speeds through the country, but it is most unfortunate to be prevented from delivering them directly to their destination. Much is gained on the road and much lost at the ends. To-day the freight stations at the railway terminals in great cities represent examples of inefficiency and confusion almost grotesque in their helpless inefficiency.

An illustration of the manner in which aerial navigation may be expected to solve this question appears in the extent to which the automobile is already acting with passenger traffic for those who wish to travel from town to country. The ordinary fashion is to expend time, effort and money journeying from residence to railway terminal, this latter being so arranged as to offer as many obstacles to convenient access as might possibly be imagined.

The journey must then be made by train to some station more or less conveniently situated with respect to the destination, after which the passenger is left to his own devices to get to his resting place.

The automobile, on the contrary, meets him at his own door in the city and deposits him at his own door in the country. True, he does not experience the privilege of gazing upon lordly halls in the great railway terminal, or of walking magnificent distances between the street and the train, but few except high railway officials will miss these luxuries.

The machine which travels through the air, instead of on the road, possesses all the advantages of the automobile, besides some others. The cry of good roads will not be heard on its behalf; the road is always open, over public and private property, regardless of ancient limitations, and the start and finish are as free as the route.

This is true not only for personal transport, but for the carriage of merchandise; and one of the controlling features of the Great Transformation must be the ability to pass from factory to warehouse, over streets, buildings, rivers and surface boundaries, without thought of interference from middlemen. A faint indication of what this means may be gathered from the difference which appears in a machine shop equipped with an overhead traveling crane, and one in which all material has to be carried about through tortuous and crowded passages upon the floor.

It is well known that many automobile factories in the suburbs of great cities maintain their own service between the workshop and the salesroom in the city, using motor cars of standard construction and enjoying entire freedom from ordinary transport inconveniences.

It must not be assumed that the routes through the air will soon be used for heavy merchandise transportation. The railway has not wholly superseded the canal, and the merchant boats still continue their leisurely way on the Rhine between the railways on each bank. The Erie Canal parallels the New York Central Railroad, and there is ample traffic to keep both fully occupied, while no one doubts that both the Panama Canal and the trans-continental railways will be kept filled with business. The route through the air, however, will serve to clear away the urgent and direct traffic, and to convey articles of moderate bulk and large value in the most direct manner at the highest speed. Heavy merchandise will, doubtless, pursue its indirect way slowly along the surface for a long time to come, although it is probable that one of the indirect consequences of the general introduction of aerial transport will be a wider diffusion of industries and a decentralization in many departments of commerce.

No great change occurs in an isolated manner, and it has already been pointed out that the time is rapidly approaching when human activity will be expended almost entirely in the direction of power-operated machinery, and that physical effort will be practically eliminated. The development of aerial transport with respect to its influence upon business must be considered as a portion of the result of this evolution, and its further progress combined with the changes which are coming in all lines of work.

One of the limitations which is appearing in the expansion of navigation upon the surface of the water lies in the practicable depths of harbour entrances. The great ocean liners have been extended in length, speed and tonnage, but at each end of the route they are compelled to encounter the difficulties of sandbars, mud banks and contracted and limited channels. The engineer is continually at work endeavouring to remove these obstructions, but they must ever be expected to oppose the indefinite extension of marine development.

The ship of the air is free, to a great extent, from such limitations. While it is true that suitable landing places are not to be found everywhere, it is undoubtedly true that the thoroughly controlled airship of the future will be able to select its landing place, and be freed from any necessity for following a specified channel. Opportunities for avoiding crowding also appear in both vertical and horizontal directions. It is possible that certain elevations may be selected for various kinds of traffic, and it is probable that swift and small personal machines may seek the higher altitudes; but it must be remembered that all such matters must come as a result of individual willingness, and that there appears to be no way in which any restrictive regulations can be enforced.

The difficulties which appear in the control of commercial vessels entering a country through the air apply as well to any attempt at blockade in time of war as to customs regulation in time of peace.

One of the most powerful weapons hitherto assumed to be available against any country, such as Great Britain, which is largely dependent upon outside resources for sustenance, has been the possibility of general blockades, cutting off, in large part, the necessaries of life, and compelling either disaster or surrender. Napoleon tried this plan in connection with the Berlin decrees of 1806, but the command which England maintained of the sea prevented the accomplishment of the disastrous consequences which would otherwise have followed. During the Civil War in the United States one of the principal sources of naval activity on both sides was found in the attempts to obstruct commerce and to evade blockade in connection with shipments of cotton outward and contraband military supplies inward, and the relations between commerce and obstructed navigation formed an important element in both instances.

When the aerial route is opened to commerce this element in the problem will be practically eliminated, and all parts of the world will be placed upon the same basis as regards such supplies as can be carried in the airships which may be available. It may not appear to what extent the use of military flying machines will be able to maintain a blockade which will interfere with commerce; but, in view of the difficulties which have been experienced in such matters upon the surface of the ocean, it seems almost certain that the infinite number of routes through the air will render any effective blockade impracticable.

One of the features which may be expected to constitute an important portion of the transformation in commerce as a result of the opening of the highway of the air is the general dispersion and decentralization of traffic. The development of railways acted, to a large extent, to concentrate manufactures and commerce along the lines which marked the routes of the railway lines; the great cities became the great commercial centres, while their suburbs and the towns along the railways were filled with manufacturing establishments. In the seaport towns there arose warehouses and factory buildings in connection with the docking facilities, and the whole influence of mechanical means of transport conduced toward localization. In many parts of the world the prosperity or otherwise of communities depended upon the railway connections which were made or withheld, while the success of great corporations hinged largely upon the extent to which they were able to make favourable transportation arrangements. These results naturally followed upon the fact that the methods of railway transport were rigidly limited by the fixed nature of their routes, permitting their trains to run only upon tracks the location of which was governed by physical or political conditions. The privileges conceded to the corporations by which such transportation lines were constructed and operated naturally included commercial advantages, which fell into the control of a comparatively small number of men, and, in general, all the elements of which the railway systems of the world are composed led toward centralization and concentration, both of place and management.

Most of these elements will be lacking in the use of the air as a general highway for commerce. The absence of any specified routes removes any necessity for concessions to operating corporations, and renders unnecessary any special right-of-way for anybody to go anywhere. There is thus no need for any manufacturing establishment to be dependent upon any outside transportation organization for the handling of its material or products, and any advantages involved in the control of cars, or choice of desirable routes, disappear, the shipper being in a position to load merchandise upon the vessel within the walls of his own establishment and send it direct to any point desired without considering any outside transportation concern whatever.

It is altogether probable that this will place the small manufacturer upon an equality, to a large degree, with his greater competitor, in view of the fact that small machines of high speed and simple control may prove as efficient and valuable as the larger merchant carriers.

The general transformation which may result appears in the dispersion of manufacturing and commerce over the general area of a country, in contrast to the present concentration at seaports and railway centres. The fact that any point in the surface of a country is equally available with any other as a shipping station takes away the need for seaport congestion, while the ability to deliver goods at any point without rehandling or warehousing removes much of the occasion for crowded business centres.

Apart from the influence which this facility for independent shipping and transport of merchandise is concerned, there must naturally follow a corresponding leveling of values in various localities for business purposes. The special advantages of situations in close proximity to harbours, railway terminals and surface transport systems generally must disappear, or be largely modified, with the diminution in importance of these centres for commercial purposes.

The opportunity for general distribution of products may have an important bearing in completing a work which the railway and the steamship have already begun—the distribution of the necessities of livelihood to an extent which shall make local distress of any kind impossible. Nearly every instance of shortage of food supply has, in recent times at least, been localized in districts difficult of access or remote from existing transportation lines. With the opportunity of reaching any such point directly and immediately, irrespective of location, the possibility of the existence of continued want must soon disappear.

In general, the transformation which the freedom of the air may be expected to bring to commerce appears to lie in the elimination of most of the restrictive elements which enable intermediate interests to control operations which are in themselves purely productive. Commerce at the present time consists largely of methods and channels which, in themselves not necessary in production or in the actual operations of transportation, yet exercise a controlling influence upon the actual manufacture and use of the work of men's hands and heads. Doubtless there will always be found necessary a number of avocations which, while non-productive in themselves, are essential in the utilization of the natural and converted resources of Nature.

At the present time, however, the restricted nature of methods of transport and handling causes these departments of industry to bear a great disproportion to those which may be classed as actually productive and intrinsically useful to mankind. It is apparent that, with the availability of a free and unrestricted highway through the air for merchandise and for individuals, many of these intermediate operations will become obsolete, releasing the individuals who now may be classed as non-producers and enabling them to become far more valuable members to the community by engaging in productive work.

The results, broadly, cannot be definitely predicted, since they must include either a general increase in the production of what are now termed luxuries, but which may hereafter be considered necessaries of life, or a lessening of the burden of labour required to produce the necessaries of life. In any case, we may anticipate a general broadening in the aspect of existence, due to the decentralization of industries, accompanied with a freer distribution of the products of those industries and a corresponding elevation in the general standard of human existence.

(To be continued.)

# METHODS OF STONE QUARRYING

By Albert Wilhelm

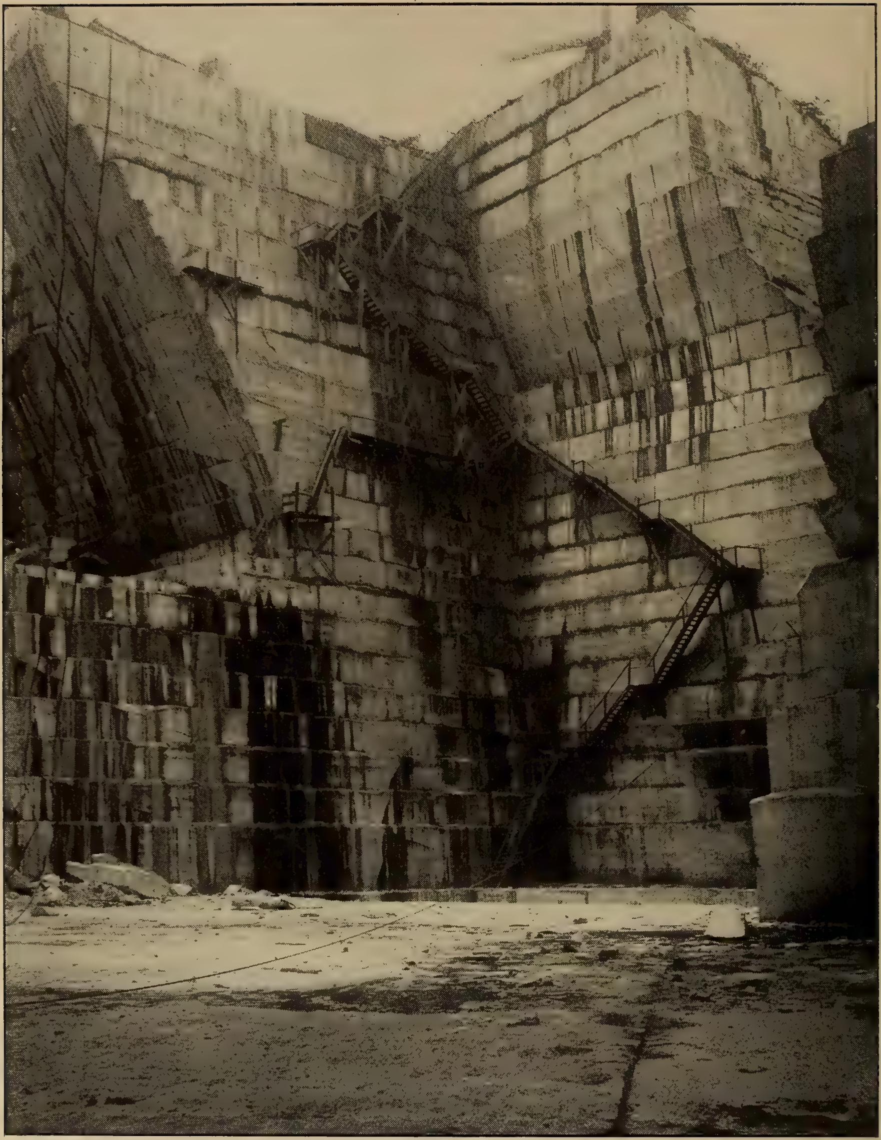
QUARRYING is one of the most important and most extensive of building industries. While it is true that compositions of clay and other material have been used in building and other operations the demand for natural stone at the present time is greater than ever before, for work which is intended to be permanent.

The United States is fortunate in having beds of stone suitable for commercial purposes located in many of the States, in deposits so large in area and thickness that some of them might be called inexhaustible. The marble, for instance, in New England, Georgia, Tennessee, Colorado and several other Western States aggregates a far greater tonnage, according to geological investigation, than Italy or any other country of Europe. The demand for large blocks of stone and marble for pillars, monuments and other work, as well as the numerous architectural and sculptural forms into which these materials are modeled, has caused the invention of modern and efficient quarrying, conveying and finishing machinery to be installed in these plants—mechanism which is notable for its power, its labour saving and its conservation of waste in contrast to the enormous loss of material which attends the hand labour methods of quarrying, especially in Italy. As a result of mechanical means the operations of a large quarry can be conducted with a small percentage of human labour where in the older days this represented a great unnecessary expense.

Stone is now being utilized for more purposes than even ten years ago. The "brownstone" fronts of hundreds of New York residences built fifty years ago are as substantial to-day as when the blocks were first laid, cut in the New England quarries. We have asphalt, gravel and burned clay highways, but the limestone "pike" is famous for its durability. The macadam road has also been laid in thousands of city streets with stone as the base. One of the principal railways of America has all of its larger bridges composed of masonry, following the example of the principal British and Continental systems. Where deposits of suitable stone are abundant by the modern mode of cutting and shaping, it can be used for bridge and viaducts at a far less expense than in the era when hand labour was employed exclusively.

As to buildings, the postoffices, for which the Government has appropriated so many millions of dollars, are all composed of marble, granite or other stone, and are not only impressive but ornamental. The same materials are utilized in the church, the college, the bank, sometimes the office building, where the owner wishes absolute safety from fire. States and cities also contribute large sums for public buildings, such as city halls and courthouses, to be composed of this material because it is capable of being treated so ornamentally and is a construction that is lasting.

Nearly a century ago the marble which outcrops on the surface of the Vermont mountains was cut off with crude tools to be used for various purposes, owing to its accessibility and its value for building operations. No one realized at that time, or for fifty years after, that the beds of the



A VERMONT MARBLE QUARRY (200 FEET DEEP). THE WASTE IS MUCH LESS WHEN WORKED WITH MACHINERY THAN WHEN WORKED BY HAND

material extended hundreds of feet below the surface, and comprised more varieties than existed in any other single locality in the world. It remained for the late Senator Proctor, who has been called the father of the American marble industry, to make an investigation which showed the really enormous extent of this hitherto unknown resource of New England.

Really the term "mining" can be more appropriately applied to this industry in New England than quarrying, for in securing the deposits, enormous chambers are excavated, some of them extending to a depth of nearly 300 feet from the surface.

OX TEAMS USED IN THE ITALIAN QUARRIES

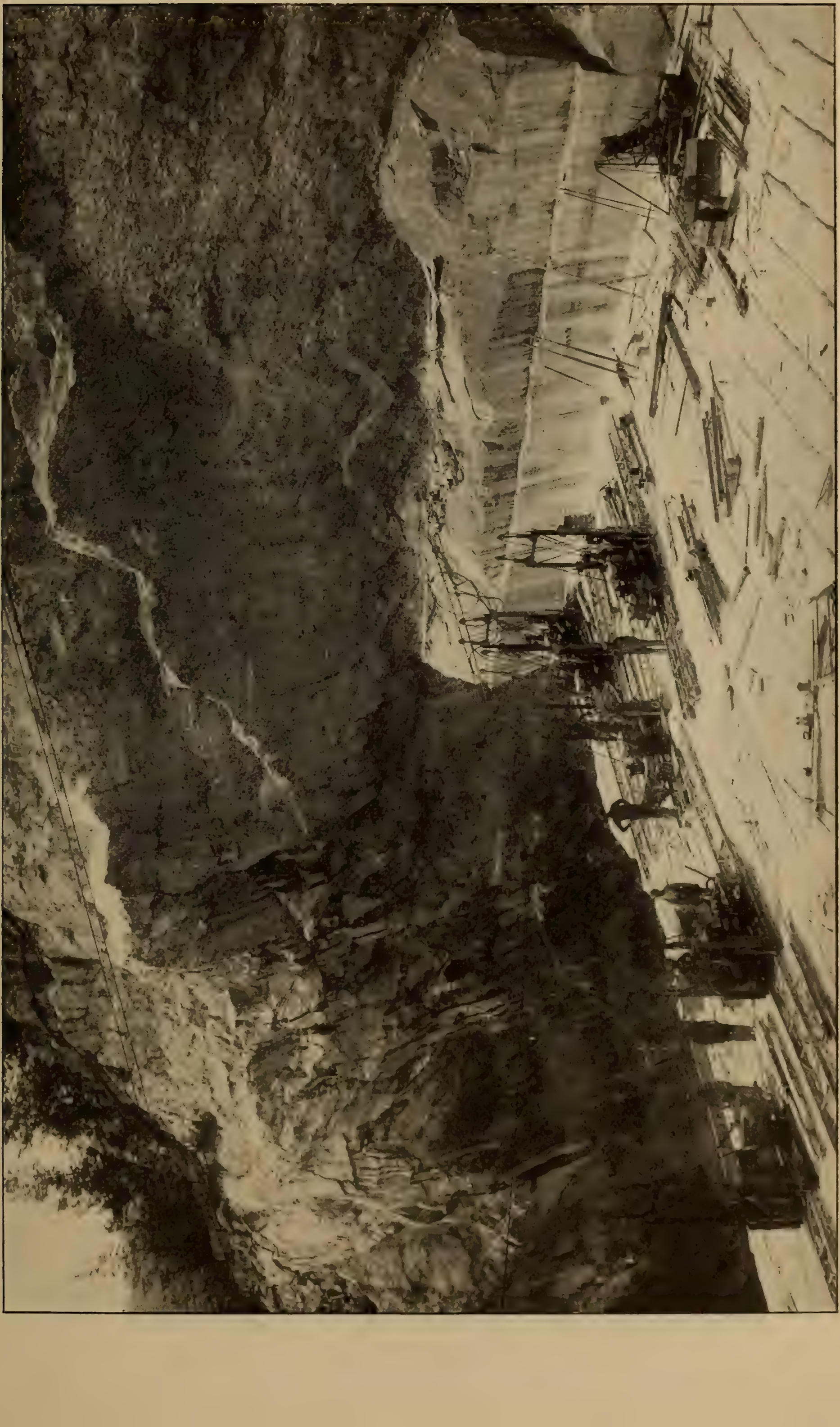
Taking advantage of the massiveness of the formation, the marble miners work for many feet underground, leaving pillars and buttresses here and there to support the sides and top, but the beds are of such size that even at the depth mentioned marble of such a high grade has been secured that it is profitable to work it. An examination of the strata as revealed by the walls of these quarries shows that several varieties, both in colour and composition, may be found in proximity with each other, the deposits occurring in regular layers separated by a natural cement, which occurs in partitions of varying thickness. The layers of marble range in width from a few inches to over 10 feet and, consequently, blocks of very large size can be secured for foundations, obelisks, and for other purposes where massiveness is required.

In securing the marble from the beds some very interesting machinery is employed. Twelve quarry hoists are operated by three-phase General Electric alternating-current motors. These are handling blocks up to 25 tons in weight. The cranes include Whiting gantry crane of 50 tons capacity, a Morgan gantry crane of 50 tons, four Shaw, three Niles, and two Morgan bridge cranes. The quarry apparatus includes Wardwell steam channellers, also a number actuated by General Electric direct-current motors. In addition to these, Sullivan steam channellers and Ingersoll pneumatic electric channellers, operated by three-phase motors are also in service.

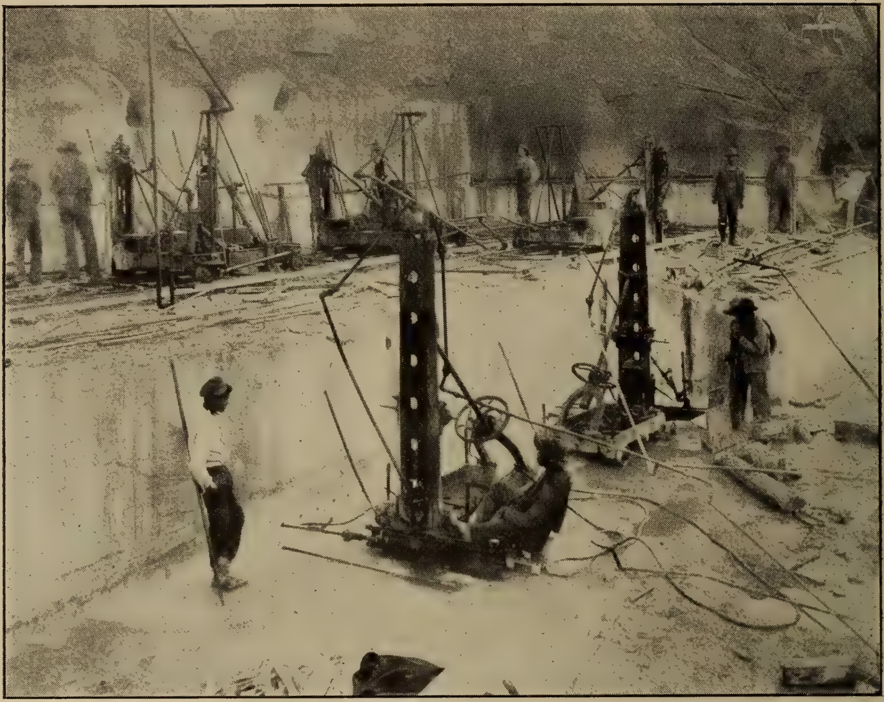
The drills are the Ingersoll and Sullivan steam-driven and the alternating current electric pneumatic Ingersoll Temple drills. The Temple drills and the Ingersoll electric pneumatic channellers are supplied by the Ingersoll-Rand Company. The operation of the pneumatic chanellers is as follows: On the frame of the machine is mounted a small motor operating an air compressor. The piston on which the drills are fastened pulsates with the piston of the air compressor. There is no exhaust of the air into the atmosphere, and therefore very little waste energy. It travels back and forth on a track which is pinned to the solid rock, making a ridge or channel which averages 1¼ inches in width and ranges from 4 to 10 feet in depth. This incision is made parallel with the rails of the channeller track, but a few inches to one side. The machine cuts but one channel at a time, and its operation is somewhat similar to the ordinary steam drill, with this exception, that the rotary motion is avoided. In order to cut the channel evenly no fewer than five drills are assembled, each having a separate bit. They are so fastened together that they act as a single tool, but having five bits. Three of the bits are adjusted directly across the channel, while two are at an angle of 45 degrees. They are clamped into a head, which forms a part of the piston rod, so that the power acts directly on the drills through the piston. The five bits combined really constitute a drill, which would be about seven-eighths of an inch by seven inches in dimensions.

The movement of the channeller on the track is controlled by a separate engine, or motor, which is geared to the trucks. The capacity of the machine depends, of course, largely upon the hardness of the formation, but frequently one hundred feet of channel will be cut in a day. It is also moved back and forth on a track, but makes a channel on each side of the track and parallel with it. In this apparatus the drills are also arranged in clamps in groups of five, the up-and-down stroke of the drills being obtained through a double system of levers connected with a crank-pin on the crankshaft of the engine. Between the levers is a system of

ELECTRIC GANTRY CRANE FOR HANDLING MARBLE



CHANNELING MACHINES OPENING UP A QUARRY IN A MOUNTAIN SIDE



ELECTRIC CHANNELERS IN OPERATION AT THE TATE QUARRY

springs, also between the lower lever and the frame, and the motion of the machine along the track is secured by connecting the crankshaft of the engine with the trucks through a system of gears. With this type of the channeller there is a constant relation between the speed of the machine and the strokes of the drill. When electricity is used in place of steam power a connection is made between the electric motor and the shaft by means of bevel gears.

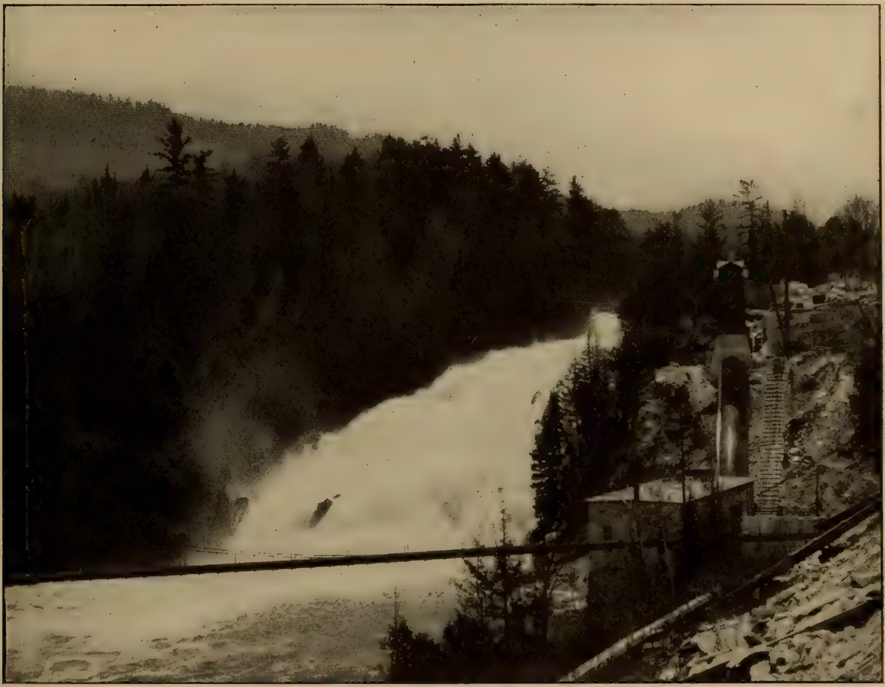
At the Vermont quarries much of the marble is fashioned into tombstones, statuary, and other forms in the mills, which have been erected in some instances immediately over the beds. For cutting the slabs into suitable sizes sand-saws are used almost entirely. The saws are made of soft iron, but without teeth, sand being substituted for the latter. The iron blades move back and forth, forcing the particles of sand against the material and thus cutting it. The sand is supplied to the marble in a stream of water which is continually poured upon the surface. The process is somewhat lengthy, for from four to five hours are required to cut through a single foot, but the number of saws give this portion of the works a large capacity.

The electrical power is obtained from the generating stations—at Proctor, West Rutland and Huntington Falls. The Proctor contains three 50-kilowatt generators, three 500-kilowatt transformers, also a 150-kilowatt motor for serving the three 1,200-horse-power Morris turbines driving the generating units, Proctor works. At Huntington Falls two Morgan-Smith turbines of 1,200 horse-power each are installed, two 750-kilowatt generators and 2,500-kilowatt transformers. Four transforming stations distribute the current to the shops, quarries and yards. The electric equipment has been installed by principally the General

Electric and the Westinghouse companies. The Allis-Chalmers Company have also placed types of their machines in the works.

The town of Marble in Colorado is so named because near it is located what is the largest deposit of this material known to exist in the West. The extent of operations of the principal producing company—the Colorado Yule Marble Company—will give an idea of the extent of quarrying in this State. The mills and shops alone cover a site 1,300 feet long and 100 feet in width. In size the plant ranks next to the Vermont Marble Company in America. The deposits now being excavated extend a distance of six and one-half miles and have a thickness of 350 feet in solid marble. About 40 per cent. of this is entirely white, as determined by borings and other tests, while the balance is of variegated tints. The beds are the highest marble beds in America, located at an altitude of 9,300 feet above sea level.

The quarries have an installation of modern drills and channellers, while the cutting and finishing mills are equipped with diamond-set saws. The marble is finished largely by abrasion and carborundum wheels. The plant and quarries are operated entirely by electric power. A sufficient head of water has been obtained from the Crystal River to generate 1,800 horse-power. By an overhead system the current is transmitted to the quarries, also to several buildings. The force of employees of the Colorado Yule Marble Company is about 500. The product of the plant is used principally in courthouses and other public buildings and office buildings.


CRYSTAL RIVER HYDRO-ELECTRIC POWER STATION GENERATING CURRENT FOR THE VERMONT MARBLE WORKS

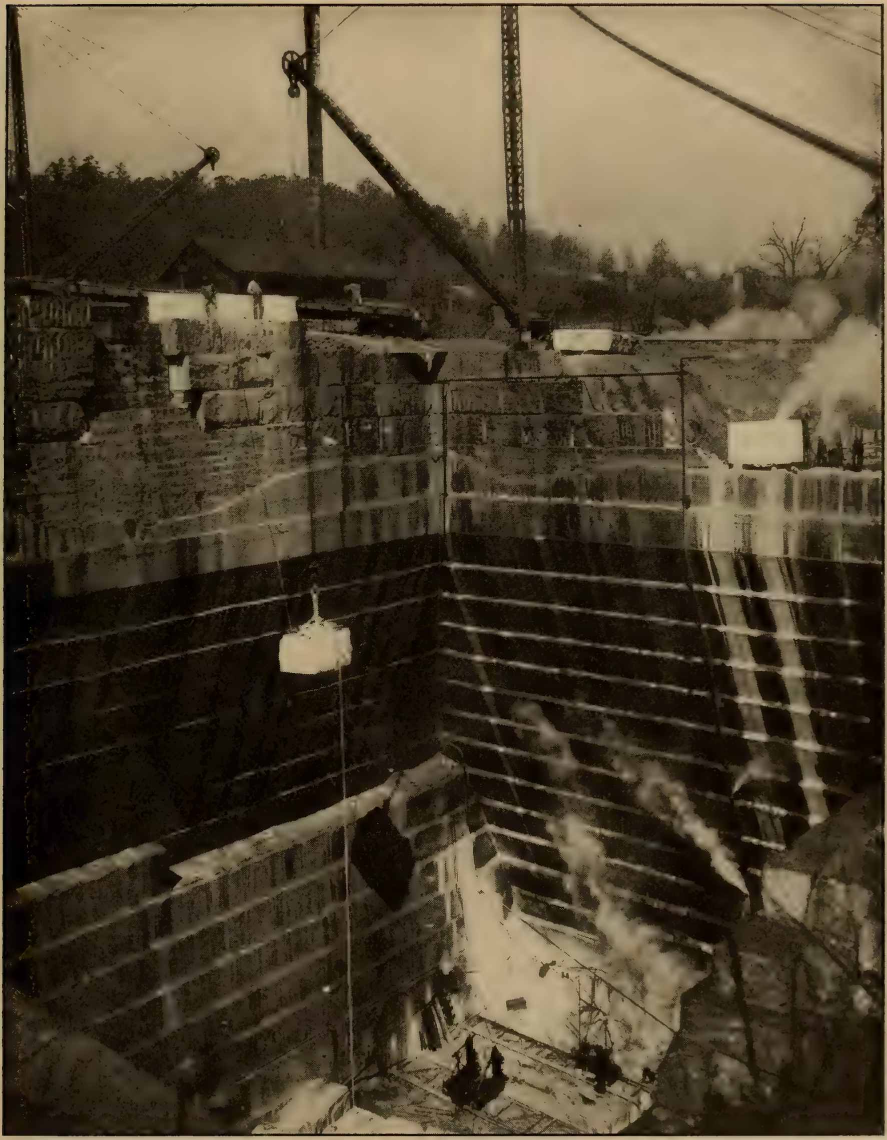
The States of Georgia and Tennessee are "Marble States" of the South. One of the most modern quarries is that of the Georgia Marble

A DEEP QUARRY OF THE GEORGIA MARBLE COMPANY

Company, located at Tate. There are three openings—the Kenesaw, the Etowah and the Creole—each noted for its tint and compactness. As the illustrations show, the work of quarrying is done by the latest models of electrically-driven channellers, compressed air drills, while steam and electrically-operated steel derricks and conveyors are used for removing the blocks from the pits. Some of these excavations are over 100 feet deep.

Ohio is noted for its sandstone deposits. One of these is being worked by the Ohio Sandstone Company, at Amherst, about thirty miles from the city of Cleveland. Here is one of the largest gray sandstone quarries in the world. It is 1,000 feet long, 400 feet wide, and in places the stone has been removed at a depth of 212 feet. The quarrying mechanism includes Sullivan steam cutters, operated by portable steam engines. The company has two mills, each containing twelve gangs of saws, and a planer department, where is planed curbing, ready to be set in the street, and mouldings, such as cornice work, etc., for buildings. The mill contains nine planers and two lathes for turning columns and balusters. A tramway a quarter of a mile in length, running the entire length of the plant, is operated by seven electric traveling cranes. This company produces stone for building purposes, curbing, flagging and grindstones, and its building stone has been used in many public buildings throughout the United States and Canada.

Indiana is an important source of valuable stone for building and other purposes. What is known as the Bedford is used very extensively on account of its quality. The extent of one company's operations and the special machines employed for cutting the stone and removing the blocks are shown in the accompany-



HOISTING BLOCKS OF MARBLE FROM THE TATE QUARRY, SHOWING DEPTH OF MARBLE

ing illustration that gives an idea of the dimensions of this quarry. This plant is located at Bedford, Ind., and is owned by the Indiana Quarry Company.

Not only limestone, but brownstone and ashlar are found in large beds of a very high quality in Pennsylvania. A group of extensive quarries and mills for converting the stone into commercial forms is located at West Grove, Pa., and operated by the Pennsylvania Marble and Granite Company. The quarries are of very large size and the plant is one of the most extensive in the State.

The deposits of the South Atlantic States contain a very large quantity of building and ornamental stone, as

THE GREAT BEDFORD LIMESTONE QUARRY OF THE INDIANA QUARRIES COMPANY

is shown by quarrying operations at Mount Airy, N. C. Here the North Carolina Granite Company are working a formation, covering an area of nearly forty acres of solid granite so compact as to be seamless. To quarry this granite a novel but effective engineering method is used, by making artificial seams. The operations consist in drilling holes and igniting explosive in them, then to enlarge the fissures made by injecting compressed air. The holes drilled are usually about 3½ inches in diameter and of any required depth, usually about 6 feet. This hole is drilled at right angles to the surface. Then half a stick of dynamite is exploded in the bottom of the hole, which forms a small cavity about 5 or 6 inches in diameter. The hole is cleaned and a small handful of black powder exploded in this cavity. This operation is repeated as many times as may be necessary to start a small crack parallel to the surface. As soon as the crack has been opened properly, more powder is exploded in the cavity, the charge increased slightly at each explosion, until the crack extends in all directions for a distance of 30, 40, 50 feet or more. This lifting process is performed during the hottest summer weather, when the surface of the stone is more or less heated and inclined to expand.

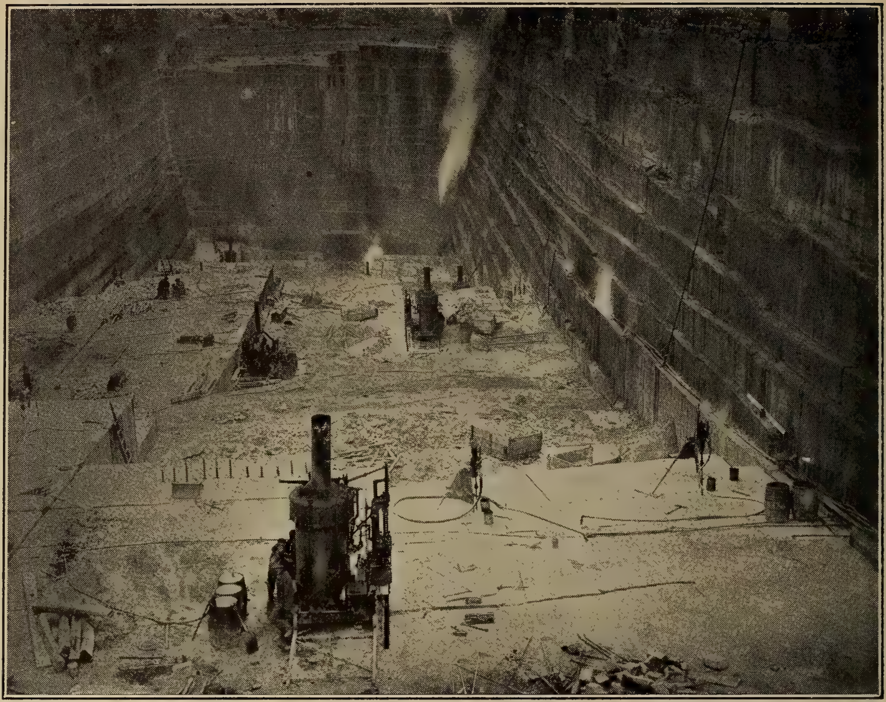
This work completed, the air pressure is brought into service by inserting usually a 1-inch pipe into the hole and confining it; then, by the use of an ordinary globe valve, the quantity of air is controlled. After the air has been admitted into this cavity, by putting the ear to the surface one can hear the stone

VIEW OF LEDGE LIFTED BY POWDER AND COMPRESSED AIR, AT MOUNT AIRY

within break and tear loose, making a sound similar to a piece of cloth when torn apart. As the compressed air raises the mass of stone gradually the natural tendency is to extend the cleavage in all directions. This operation continues until after the whole area covering from 1 to 3 acres has been loosened from the main mass of stone.

The separation completed, the layer of granite which has been severed from the deposit is ready for reducing to commercial shapes. The idea of the magnitude of this work will be realized when it is stated that the stone is so compact that it weighs 165 pounds to the cubic foot. Taking 144 square inches of area to the square foot gives approximately 1⅛ pounds of weight to raise per square inch of surface for every foot in depth; therefore, to raise a sheet of stone 6 feet in thickness it is required to lift 6¾ pounds of weight per square inch of surface. About 90 pounds pressure is in the air pipes distributed throughout the quarries.

The quarries are equipped with eight cableways which handle the stone from the quarries to the railway cars, which are located at the base of the deposit. These cableways are operated by double cylinder, double-drum engines of the American Hoist and Derrick Company make. In addition to these cableways are two inclines, which are used to handle blocks too heavy for cables. The inclines are equipped to handle stones up to 60 tons weight, or heavier, if necessary. The stone-cutting plant is equipped with two 20-ton Pawling & Harnischfeger Electric Travelers, 50-feet span, each being equipped with a 5-ton auxiliary hoist. A 100-kilowatt direct-connected generator furnishes the current for the cranes. A

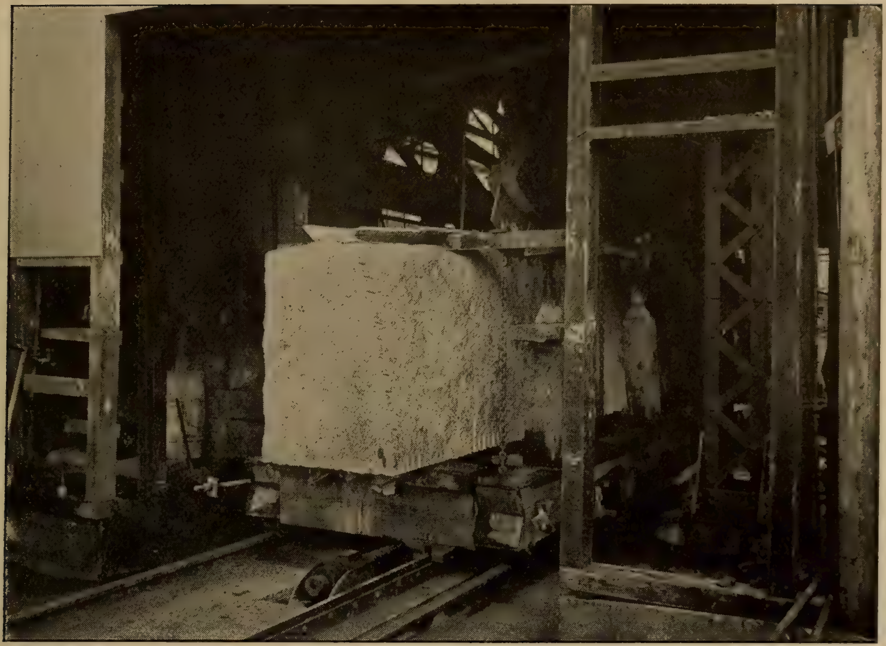


VIEW OF BUCKEYE QUARRY, SHOWING SULLIVAN TYPES OF MACHINES FOR CHANNELING AND COMPRESSED AIR DRILLS

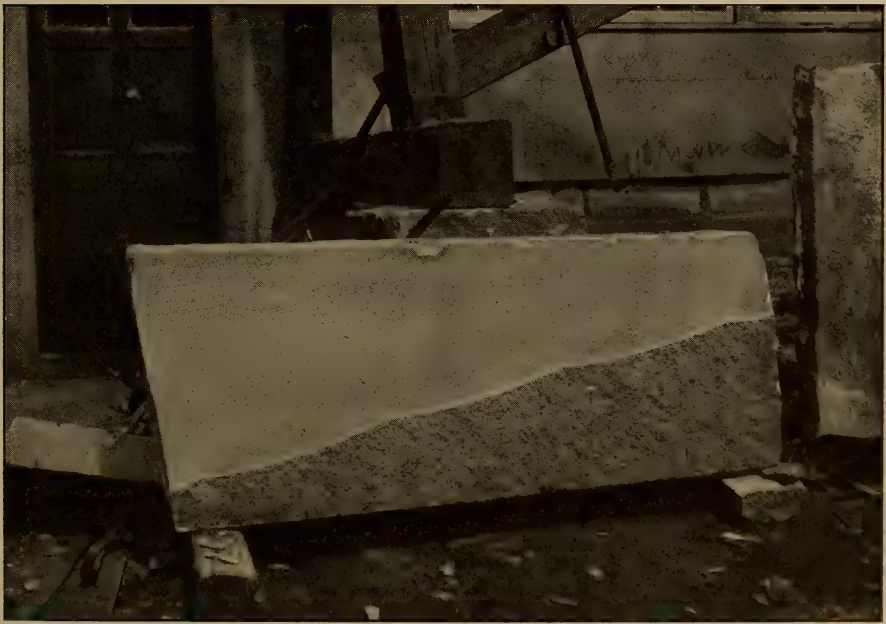
cross-compound Corliss air compressor of 2,000 feet capacity, made by the Sullivan Machinery Company, furnishes air for the plant. Two Heine water-tube boilers, each 220 horse-power, are used in the power house. Crushing plant No. 1 is equipped with a 50-horse boiler and engine and a Gates crusher, screens, etc. Crushing plant No. 2, which is now being completed, is equipped with two 150-horse power tubular boilers, Hamilton-Corliss engine of 250 horse-power, a No. 7½ and No. 5 Gates crusher, two sets of 16-in by 36-inch Sturtevant crushing rolls, elevators, screens, etc., with storage bin capacity of 1,000 tons. The track facilities in the quarries and cutting plant are adequate for 100 cars, a locomotive being kept in the yard constantly to handle the shifting.

The illustrations show the sizes of finished blocks which the company quarries for public buildings, such as city halls and courthouses.

As already noted, the development of quarrying mechanism has greatly progressed within a few years. One type of such machines is the Wardwell stone quarrying and channelling machine installed in the Vermont quarries, as already stated. It is made by the Steam Stone Cutter Company, of Rutland, Vt. There are two types—a single gang and double gang. The double-gang machine is the one mostly in use and is adapted for all kinds of stone, except grit and sandstone, and is mounted on a steel rail track on the bed of the quarry. The frame which supports the boiler, engine, and other machinery, consists of one piece of forged iron, weighing nearly a ton; the engine is of 6 horse-power, its shaft carrying a balance wheel on each end, to which is attached an adjustable wrist-pin plate. The levers which operate the gangs of cutters are pivoted at their rear ends to an extension of the frame. The free



FRONT END OF CHASE PATENT SAW IN ACTION



A STONE BROKEN IN TWO AFTER IT WAS PARTLY SAWED BY CHASE PATENT SAW, SHOWING THE ACTION OF BLADES ON THE STONE

ELECTRIC DRILLS CUTTING UP A BLOCK OF MARBLE DISLODGED FROM THE MOUNTAIN AT CARRARA

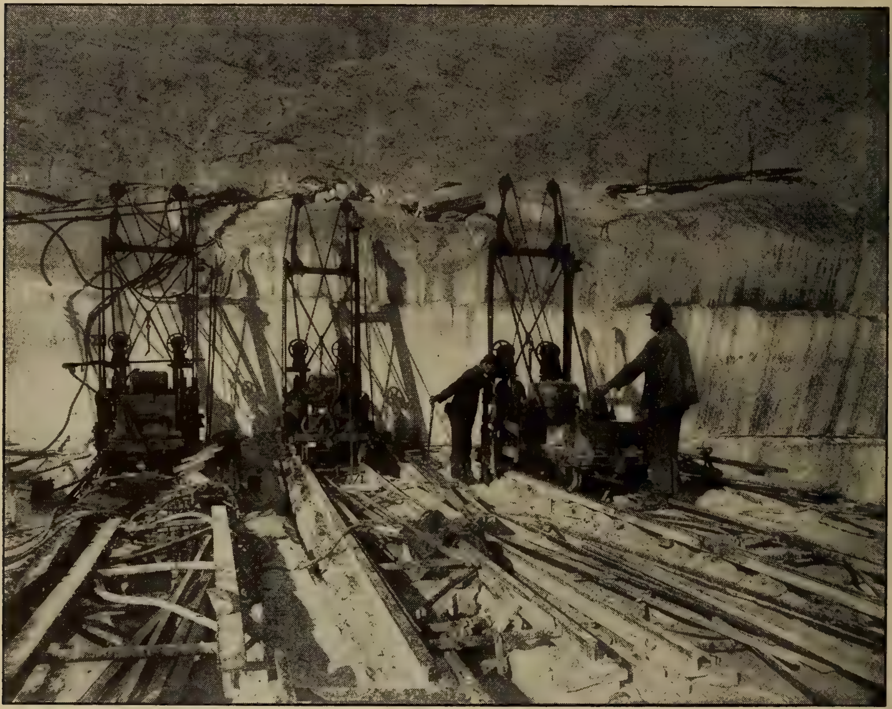
end of the lower lever actuates the gang of cutters, which consists of five bars of the best cast steel, sharpened at their lower ends, and clamped together by head and foot clamps, the whole sliding freely on the standard. Of the five cutters two have diagonal cutting edges and three have their edges transverse. The centre cutter extends the lowest and they all together form a stepped arrangement each way from the centre; thus when the machine is moving forward the three cutters, which includes the centre one, operate, and while in the opposite direction the other two with the centre one perform the work. The object of the diagonal cutting edges is to insure an even bottom to the channel to be cut. These bars of steel are from 7 to 14 feet in length, according to the depth of the channel to be cut.

Another movable type of mechanism is the Chase granite saw, manufactured by the American Granite Saw Company, of Worcester, Mass. It consists of a set of cutting blades of hard steel set in a framework of structural steel. The seven blades are bolted to a connecting bar and the sections used for sawing extend forward as an angle so that the first of front blade merely makes a slight incision in the stone. The second blade projects lower than the first, the third hangs below the second, and so on to the last blade, which extends below all the others. In this way a much greater force can be exerted in sawing than where the blades are set evenly. The stone to be sawed is carried under the saw on a steel trunk and the saw adjusted. The length of stone to be sawed is limited only by the capacity of the quarry to produce long blocks. The material is first loaded on cars and advanced forward to the blades by means of a screw 35 feet long, which is constantly pulling the car through the machine, thus enabling the saw to make a continuous operation. All that is necessary is to keep the stone loaded on cars in front of the saw, then as the car emerges from the

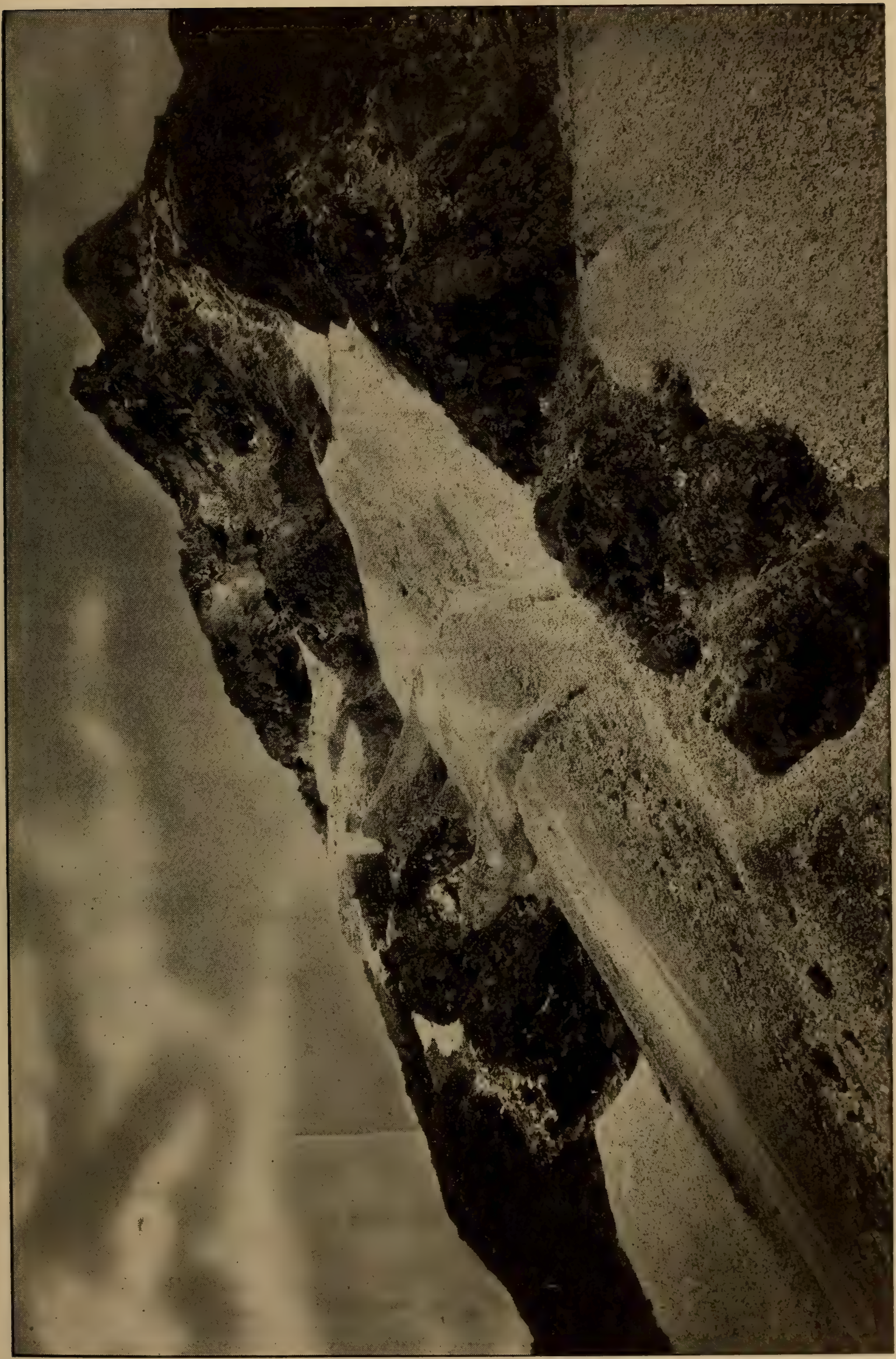
METHOD OF MOVING THE LARGE BLOCKS IN ITALY ON "SLIDES OF DEBRIS"

TATE QUARRY, SHOWING FORMATION OF MARBLE AND BLOCK FOR REMOVAL back end of the saw the stone is cut in two and the car unloaded, replaced in front of the saw and reloaded.

What modern machinery in quarrying means in saving time and labour and in economizing waste may be better realized by contrasting American methods with one of the oldest quarries of Italy, the Carrara. Twenty centuries ago men were digging out the side of the Apuan Mountains, in Italy, for as far back as that time they realized what could be done with the marble which composes so much of this mountain range. The mines or quarries are only within a few square miles of territory, but an army of 6,000 men and boys are continually employed, their earnings supporting 100,000 of the people of northwestern Italy. No one knows how much marble is contained in this range of Italian mountains. Though they have been opened for 2,000 years and, as stated, the mining methods are attended with enormous waste, it is known that vast beds of the marble still exist. By digging longer and longer tunnels and shafts an inexhaustible supply can be obtained, for the beds are so extensive that some of the mines are worked at a height of over a mile above the sea, while many of the workings are over 2,000 feet above the sea. This is a great advantage to the Italians, however, because methods are still in use in quarrying and getting out the marble which are hundreds of years old. But little advantage has been taken of the modern labour-saving machinery, such as electric and compressed air drills and saws, the principal tools being steel bars and chisels, mallets, while not only dynamite but gun powder is placed in big holes, exploded, and frequently the side of the mountain



ELECTRIC CHANNELLING MACHINES IN USE IN QUARRIES OF VERMONT MARBLE COMPANY; ONE MACHINE DOES THE WORK OF FIFTY MEN, LEAVING VERY LITTLE WASTE



THE GREAT SLIDE OF DEBRIS AT CARRARA, SHOWING THE WASTEFULNESS OF OLD-TIME METHODS

GIANT STRING OF OXEN HAULING MARBLE IN CARRARA, ITALY

will be so shattered by the explosion that the waste marble is much more than the block which is loosened. The height of the quarries, however, allows the block to slide down the slopes of the mountains by gravity, and in this way a mass weighing so much that it could not be lifted by the power available can be lowered by means of block and tackle to the foot of the mountain to be shaped into a form so that it can be sent away.

While some of the miners have drills operated by steam and electric power, much of the work is done with the hand-power mill. Apparatus for grooving the marble has not as yet been employed, except in a few works, the bulk of the product being obtained by blowing it out. The

BIRD'S-EYE VIEW OF CARRARA, THE MARBLE CITY holes are drilled where, in the judgment of the quarry director, the explosive will be most effective, but before being charged they are usually enlarged by pouring nitric acid into them, which eats away the interior. The explosive is then inserted. In recent years the electric current has been used to ignite it, but in many of the larger operations the fuse is still employed.

The charges are not always so distributed that the block desired is loosened, so a second blast is frequently necessary to completely detach the mass, when some of the needless surface is cut off on the spot with chisel and mallet. Then the material is ready to be transported to the marble mills in the valley or to Avenza for shipment by water. As the quarry may be several miles from the railroad advantage is taken of its height. If the marble is a very large piece an inclined plane may be made, down which the block slides upon a wooden sledge, controlled by ropes fastened about it, which are run through pulleys so that the speed can be regulated. At the foot of the inclines it is placed on a clumsy but strong cart, drawn by oxen. Sometimes a string of twenty or more of these beasts are hitched to the cart by means of wooden yokes of the pattern used a hundred or more years ago.

To save the expense of transporting refuse material a considerable amount of the marble is sawed and finished at Carrara, but here again most of the work is performed by antiquated machinery. Works where the slabs are actually sawed by hand are numerous. A crude frame, somewhat resembling the old-fashioned American buck-saw, but much larger, holds the saw blade, which is usually of steel, and when new is about 5 inches in width. This is pulled back and forth across the surface of the stone by two men, one at each end of it. Water flows along the cut from a wooden trough resting on one end of the block, and thus the metal is cooled. The work is so slow, however, that a groove 4 inches deep is considered a fair day's work, for which each man receives the equivalent of about 35 cents in American money. Steam power is used more extensively for operating the finishing tables, where the slabs are smoothed and polished while rotating beneath pumice and wooden polishing blocks, although some of this labour is still performed by hand. Such is the extent of the waste that some of the heaps of marble scraps are hundreds of feet in height and may cover the slope of a mountain to a depth of a thousand feet. In cutting the marble the miners have been so careless that they have thus covered many of the deposits so that they can never be worked without removing these piles of fragments, which would be a task requiring many years.

To the engineer it may seem curious that the Italians do not use more machinery driven by electricity and compressed air, since one of these drills and cutters can do as much in a day as a hundred men with hand tools; but these people have peculiar ideas. Many of them are very superstitious, and think that these inventions are the work of the devil. They also object to them because they know that one will do the work of so many men in a day. They are afraid the machines will drive them out of employment. In Italy, as well as in the United States, there is the labour union, and in some of the largest mines these organizations have prevented the lessees from using machinery which would greatly increase the output and at the same time reduce the quantity of waste.

# THE RAILWAYS OF BRAZIL

### By Lionel Wiener

### XV.—GENERAL REVIEW AND CONCLUSIONS

In the preceding article of this series the various railway systems of the different parts of Brazil have been described, and the author now brings the subject to a close by examining the relations of further extensions of Brazilian railways to the industries of the countries from which large portions of the material and equipment must be drawn. Great Britain, the United States, Belgium, Germany, these and other countries are interested in the development of this great and growing market, and the review of which this is the closing article should result in bringing to the attention of engineers and manufacturers the possibilities which are thus offered for commerce and trade.—THE EDITOR.

THE preceding article, describing the railways of the Rio Grande do Sul, closes our examination of the various railway systems of Brazil, their history and their future prospects. There are some other points, however, which should be discussed before this survey may be said to be complete. These relate to the present relations of Great Britain and other countries to the railway industries in Brazil, and also to the present situation of the Brazilian railways themselves. Not so very long ago British capital was drawn upon almost exclusively to supply the needs of Brazilian railways, and many of the roads owe their very existence to the early British companies which were floated to build and operate them. Since those days, however, several of the British companies have turned their lines over to others, and various companies have stepped in, altering the situation very materially. This would be of little moment if it were not for the fact that orders for equipment and supplies generally go to the country by which the line is operated, and not necessarily to the one which has loaned the capital.

It is often a point of criticism that capital is subscribed by one country and orders for material and supplies go elsewhere, but this vexed question does not always receive a fair consideration. It should be remembered that a railway company, other than that of a State-owned railway, is conducted for the prime object of securing dividends for its stockholders. When money is needed it is borrowed, at what is considered by both parties to be a fair rate of interest. The company receives the money, to be expended at its discretion; the lender receives the interest which he considers fair, and the transaction is closed. Such a transaction does not carry with it any obligation to spend the money in any special country. If the country by which the loan is made considers this necessary, a clause to this effect should be inserted when borrowing, as France recently wished to do with Turkey, and then the conditions of the loan will be altered.

It must be taken for granted that any company will naturally desire to buy its material from its own people, and if this is not done there must be some good reason because of which the country of the undertakers cannot provide satisfactory material under as good all-round conditions as can some other. The Compagnie Auxiliaire, for instance, and the Chemin de Fer Sud Ouest Brésilien, have operated railways in the Rio Grande since 1894, and yet down to 1911 neither of these roads have ordered Belgian locomotives, although both lines are Belgian by ownership.

A well-known British railway journal has found fault with both the government of Argentina and with the province of Buenos Ayres because loans for railway purposes have been subscribed in England and all the plant has been purchased elsewhere. Such criticism is not justifiable; the subscription to the loan is purely a financial transaction, and we may fairly assume that it has been profitable, considered by itself.

If the plant has not been bought in England, either the manufacturers have been caught napping or else they have not been able to produce what was desired better than anyone else. This should be considered as a well-deserved lesson, and not as a cause for complaint.

There are still three important Brtish railways in Brazil: the Great Western, in the northeast corner; the Leopoldina Railway, in the central group, and the Sao Paulo Railway, between Santos and Jundiahy, this latter being a single railway, but the key to a State. If to these we add the North Eastern (Ceara State), the Bahia Railway (temporarily), and one or two other small lines, such as the Sao Paulo & Minas and the Brazil Great Southern, we have all. This means not only that some lines have changed hands, but that other countries are making more rapid progress.

The Franco-Belgian Railways are represented by the important Rio Grande Railways, the three important penetration lines, the North West of Brazil to Corumba, the Goyaz Railway and the Victoria & Minas, and the new Colossus, the Brazil Railway, which, though American in nationality, is more Franco-Belgian than anything else, through its capitalization and the part of the lines which it has taken over.

Germany has succeeded in getting only a finger in, which is curious when we consider that South America is full of German colonists. She now has only the short Santa Catharina Railway, but further concessions will probably be secured.

Geographically considered, all the southern portion is Franco-Belgian; the centre, comprising the States of Sao Paulo and Minas, is Brazilian, and most of the east coast is British.

This, however, is not sufficient to give a clear idea of the nationality. The construction work is largely carried on by French companies, while rolling stock of all descriptions is purchased to a great extent in the United States. Thus, on the system of the "Union," which, on January 1, 1908, consisted of 7,795 miles out of a total of 11,646 miles, there were 1,074 locomotives, 1,324 passenger carriages and 14,221 wagons in use. Of the locomotives, 704 are from the United States, 318 are British, 23 French, and 30 are Belgian or German. The large proportion from the United States is due to the fact that the Central of Brazil uses American rolling stock almost exclusively, their proportion including 322 locomotives.

In the coaching stock there are included 483 from the United States (of which 208 are on the Central of Brazil), 348 Brazilian (241 of these belonging to the Brazilian Railway, which owns but four coaches built in Europe), 395 British, 71 Belgian and 27 French.

Of the wagons, 7,073 are British (the Sao Paulo alone owning 2,903), 2,996 are Brazilian (the Central owning 2,201), 2,397 are from the United States, 1,254 are Belgian and 451 are French.

These figures include most of the railways of Brazil, but a large mileage is stadoal and not included in these figures, this amounting altogether to 3,851 miles. A large portion of this mileage is in the hands of the three principal Paulistan companies—the Mogyana Railway, the Paulista Railway and the Sorocobana Railway. On December 31, 1909, they owned rolling stock as follows:

| | American. | Brazilian. | British. | German. | Belgian. | French. |
|---|---|---|---|---|---|---|
| Locomotives... | 199 | 4 | 134 | 5 | 0 | 1 |
| Coaches ...... | 186 | 256 | 44 | 0 | 10 | 0 |
| Wagons ...... | 899 | 2,526 | 1,861 | 2 | 402 | 31 |

A few lines of these companies were conceded by the government of the Union. The corresponding rolling stock, which is counted both ways and should be deducted, consists of:

| | American. | Brazilian. | British. | German. | Belgian. | French. |
|---|---|---|---|---|---|---|
| Locomotives... | 64 | 0 | 25 | 0 | 0 | 0 |
| Coaches ....... | 57 | 49 | 9 | 0 | 2 | 0 |
| Wagons ....... | 519 | 510 | 911 | 0 | 111 | 0 |

American rolling stock very deservedly holds a foremost position. Its construction is very different from that of European material, its characteristics being robustness, ample wearing surfaces, easy means of taking up wear in all parts, simplicity, and general interchangeability. A locomotive built with these points in view is bound to be heavier for its power than a European engine, and it is also apt to consume more fuel and lubricants. Such an engine, therefore, should be used in localities where these qualities overbalance the drawbacks of its defects. It is unnecessary, it seems to me, to use such an engine upon a firmly-laid, stone-ballasted European track, on which a good engineer can get the most out of delicate service. On a rough track, however, such as is commonly found in Brazil, unprovided with stone ballast, and apt to be in poor condition after the rains, and especially upon lines on which the engine drivers are not of the highest ability, a locomotive which is capable of bearing ill usage and of sustaining unusual strains is invaluable. I do not desire to claim that these engines are good merely because they are American, but I certainly advise builders to use the American axle box and the Richardson balanced valve.

The European builder does not fully realize the character of the road for which his rolling stock is being built. He is told the weight of rails, the minimum radius of curves and the maximum grade, and is also told that his locomotive must haul a train of specified weight around to one and up the other at specified speeds. The builder may turn out an excellent engine, conforming to these conditions, and yet he will frequently get no second order. This is because his product does not comply with certain unwritten conditions, as does another. Thus, there may have been a landslip, and the line has been repaired—approximately. The original curve radius of 100 metres may have become 70 metres, and a grade of 30 millimetres per metre have become 34 millimetres. These are actual figures, and do not form a hypothetical case.

The maximum grade up the Serra do Mar, on the Central of Brazil Railway, is supposed to be 1 in 55; but, in fact, it is often 1 in 41. The builder cannot be blamed if his engine does not answer to these "improved" conditions. It does not follow that he will be held responsible for these changes, but, nevertheless, his locomotive will not do the work, and the railway will look elsewhere for further purchases. The remedy is simple: an engineer should be sent out to spend some time traveling over the road to observe the handling which the rolling stock receives, and thus learn how much margin should be provided. It is much worse not to secure a second contract than not to have got any.

American and German firms understand very well the importance of keeping in close contact with the actual conditions on Brazilian railways, and hardly a fortnight passes without the arrival of some representative of a builder to visit and study the various roads. Builders who are thus represented will know what they are about when an order is secured, and, in many instances, orders may be obtained on the spot, saving much time and trouble. So far as I am aware, no British or Belgian firm has sent out an engineer to study the actual conditions on the roads, at least not for a long time. British representatives do go out to Brazil, but they visit their own people only, and that is the real mistake.

I believe that British visitors do not inspect the railway lines because they do not realize the importance of doing so. A large number of British journals quote only British concerns, and the belief thus grows that these are the only ones worth being quoted. That they are worth being quoted is beyond doubt, but if others are not also mentioned a false impression is apt to be created. Had a different policy been pursued it is probable that the competition which now exists in Argentina to-day would be hardly existent, instead of being a very active reality.

Thus, a well-known publication, referring to Brazilian railways, says: "The central group, the Great Western and the Brazil Great Southern Railways, are the most important systems." As a matter of fact, the Brazil Great Southern is quite a local line, and a number of important roads have been left out altogether, such as the Ceara System, the West of Minas Railway, the Northwestern of Brazil, the Sao Paulo & Rio Grande, and the Rio Grande System.

It is also misleading to speak of the "typical British solidity." A fine, well-built line is, of course, a splendid piece of engineering; but such lines cannot always be paid for in South America, and light, economically-built roads are frequently useful, and even unavoidable, especially in traversing sparsely populated provinces.

A point demanding especial attention is to take nothing for granted when building a locomotive for a new country, but to examine every detail closely, since the design of a locomotive must be largely the outcome of a natural evolution. If there are so many American locomotives in Brazil there must be some good reason for it, some qualities which adapt it to the country; otherwise, during so many years the railways would gradually have turned to some other type. This applies not only to the locomotive, but to the rest of the rolling stock; but as there is less difference here the fact is not so apparent.

Coming now to the subject of the present condition of the Brazilian railways, there have been many new developments even during the few months in which this serial has been running.

The general tendency appears in an endeavour to turn isolated lines into systems, and to lease them to working companies, who undertake, not only to complete them, but also to establish colonies along the lines.

The principal of these new groups are the Ceara Railway System, leased to the North Eastern Railway; the group of lines which we have called the Bahia Intermediate System, and which has actually been united and leased as a single undertaking, and the Rio System, a conglomerate of odds and ends in between Rio and the South Minas Railway, which had been formed a few months previously.

We will state briefly the bearing of these alterations:

### NORTH OF BRAZIL RAILWAY

This company was intended to build a series of lines along the banks of the Tocantina and Araguaya rivers, connecting the various navigable portions by covering the various stretches upon which the rapids render the streams impracticable to navigation. Recently, however, the government has considered it expedient to make this a trunk route inland between the south and Belem. Instead of being a series of short stretches of railway, therefore, there will be but a single line to a point beyond which navigation up stream is possible without interruption.

The through route will be by the Goyaz Railway to Leopoldina, on the upper Araguaya river; downstream by steamer to Maraba and the confluence of the river with Tocantina, on by rail to Alcobaca, and by steamer again to Belem. Both the steamer service and the intermediate stretch of railway belong to the

North of Brazil Railway Company. A third steamer service must be maintained up the Tocantina river, from Maraba to Porto Nacional, or Palmas, in the State of Goyaz.

The same decree (September 27, 1910) grants a subsidy of 60 contos annually to the Tocantina and Araguaya lines, and 30 contos annually to the Belem line.* This concession has been granted for sixty years, instead of five or ten years—a decided improvement over former ones.

The 6 per cent. gold guarantee (counting the milreis at 20 pence, for the first time, I think) applies to the first thirty years of the operation of the line of the railway. One-half of the receipts—over 8 per cent. on the capital—are returned by the company to the government as repayment for sums advanced on the guarantee. When such sums shall have been entirely repaid the government may oblige the company to reduce its tariffs proportionally to the amount in excess of 8 per cent., which would have been the share of the government. The older concessions allow government interference in tariffs only above 12 per cent., and do not specify for what amount.

### THE CEARA RAILWAY SYSTEM

The Sobral Railway, the Baturité Railway and their extensions and junctions have been amalgamated so as to form the Ceara System, which is leased to the North Eastern Railway as a working company, the construction work being carried on by the South American Construction Company. The Sobral Railway extension is open or under construction from Cratheus to Therezina, whence there is a "trans-bassin" line to Caxias.

The extension of the Baturité Railway is now open from Senador Pompeu to Affonso Penna, a distance of 49 miles. Construction is being carried on towards the Serra do Araripe, a distance of 155 miles, and will probably be continued to Cabrobo, on the banks of the Sao Francisco, where it will be connected with the Bahia system of railways.

The Sobral and Baturité Railways will be connected with the three principal penetration lines of the Great Western Railway. The rental consists of 20 per cent. of the net earnings above 1,000 contos of reis, besides a percentage of the gross earnings, which increases with each increase of these earnings.

### THE BAHIA RAILWAY SYSTEM

This system consists of the Sao Francisco Railway and the Bahia & Sao Francisco Railway and branch, the open portions of the Timbo & Propria Railway, and the Central of Bahia Railway. The first of these is leased definitely and all the others provisionally to the same operating company, which has undertaken to convert the Bahia & Sao Francisco Railway from broad gauge to the metre gauge.

### THE FLUMINENSE OR RIO SYSTEM

This system differs from the others, inasmuch as it is really one system within another. Its object is not so much to unite the railways of a certain district into the same hands as it is to unite certain railways only, leaving out the main lines already in existence, and to build a few connections where the several portions are closest together, and thus to overcome the difficulty arising from the lack of a trunk road.

Such is the basis upon which the government is forming the railway which is to connect the West of Minas Railway and the Goyas Railway with Rio and the coast.

The Federal decree of June 16, 1910, states that the following lines shall be amalgamated:

The Uniao Valenciana Railway (now a line of 1.10-metre gauge from Desengano to Rio Preto); the Rio das Flores Railway (a metre-gauge line from Comercio to Tres

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* A conto is 1,000 milreis. The milreis, paper, is worth 15 to 17 pence; the milreis, gold, is worth 27 pence.

Ilhas, and which will be extended to Parahybuna instead of the existing tramway); the small Vassouras Railway (2 feet gauge, which will be widened to 1 metre), and the Auxiliar line, which will be severed from the Central of Brazil Railway.

In order to enable the West of Minas trains to get on to these lines, the newly-formed South of Minas system will be shorn of the Baependy & Passa Tres section, and three connections will be built, as follows:

From Santa Rita (on the South Minas) to Rio Preto (on the Valenciana Railway; from Santa Rita (on that same railway) to Taboas (on the Rio das Flores Railway); from Vassouras (end of the Vassouras Railway) to Portella (on the Auxiliar line).

A third rail will also be laid on a portion of the Central of Brazil Railway between Barra do Pirahy junction and Desengano, which will allow the trains of the new system to run along this route. Thus a West of Minas train arriving in Barra do Pirahy, where the freight was formerly transferred to the broad gauge and sent straight down to Rio, will henceforward have to run around via Vassoura, Portella and Belem, four times the distance to that town by the old route.

The law already quoted provides for the buying up of these minor roads and their merger at a later date with the West of Minas Railway, both groups thus becoming a single system. There seems to be some discrepancy between the formation of this new system, on the one hand, and the continuation of the construction work, on the other hand, which has been again taken up on the West of Minas extension to Angra do Reys.

The proper grouping of these railways in the south of the State of Minas Geraes seems to be more difficult than any other in the Republic, and a proper *modus vivendi* does not yet appear to have been reached.

These lines, which have until recently been developed only in accordance with local conditions, are, broadly speaking, situated in a quadrangle, the southern and eastern sides of which are, respectively, the Sao Paulo and the centre line of the Central of Brazil, while the western side is the main line of the Mogyana Railway. Now, if the interior lines of the quadrangle were combined with those of the Central Railway, converging towards Rio, which is just under the right-hand corner, the outcome would probably be a sound system. If combined with the left side—that is, with the Mogyana system—it would not be so good, but would still be a possible solution, aiming at Sao Paulo and Santos as its goal. But by leaving out the sides altogether and running the line down to Rio and Angra is possible, but much more arduous, and explains the backwardness of what might otherwise have been a good system.

Thus we have reviewed the railway system of Brazil as a half-century of work has formed it. With all its drawbacks, its gaps and its mistakes, many of which were inevitable, there is no doubt that it is still a magnificent testimonial to human energy and skill, and that the Republic now holds rank among nations in which civilization has done good work.

# METHODS OF IMPACT TESTING

By Professor C. A. M. Smith, M. Sc.

IN the reciprocating parts of a steam engine it has been estimated that about 90 per cent. of the stresses are those which include, in varying amount, shock.* In recent times there has been a tendency to "speed up," and nowadays machines are run at a quicker number of revolutions than a decade since. Moreover, the internal-combustion engine is obviously subjected to greater stresses, due to shock, than the steam engine; and the employment of internal-combustion engines is extending.

It is, therefore, obviously a matter of importance to determine whether materials used in quick-revolution machines are capable of withstanding shock. The fact has only been fully appreciated during (comparatively speaking) recent years.

## DIFFICULTIES OF TESTING

The above statement makes the matter appear simple. A piece of material is to be subjected to shock. What is more easy than to test it under similar conditions? But the problem is not quite so simple, as we shall see. Let us examine the various machines that have been devised for the purpose of making these tests.

## TYPES OF IMPACT TESTING MACHINES

Broadly speaking, all of the machines in use at the present day fall into one of two classes. They are:

(1) In which the material, in the form of a round bar, is subjected to a suddenly-applied tensile stress.

(2) In which the specimen is supported like a beam and is broken by a transverse impact load. Such specimens must be notched, in order to ensure that they will fracture at the required point.

In both cases the results are usually only comparative, specimens of the same dimensions being used throughout. In a series of tests the number of foot-pounds of energy required to break the various specimens is taken as a measure of the ability of the different materials to withstand shock.

## (1) TENSILE IMPACT TESTING MACHINES

The simplest method, clearly, of seeing whether a material will stand a certain shock is to make a rod of it as shown (Fig. 1) and drop a known weight $W$ pounds through a certain height $h$ feet. The work done by the weight is then clearly $W \times h$ foot-pounds. If the material is fractured the area is insufficient to take the shock stress. We may, therefore, proceed to test either by taking pieces of the same material, using rods of greater diameter, or employ weights which gradually become less in value. Finally, we shall just reach a point at which the rod will not fracture. Unfortunately such a series of tests would take a long time to carry out and would use up a quantity of material. Therefore, while an apparently simple method, it is impracticable.

Such a test as outlined above is called a tensile impact test, because, if the weight is so arranged that the load acts axially on the specimen, there are no bending or other stresses, except tension, upon the material.

The next step in the evolution of the tensile impact machine is as follows: The specimen to be tested is gripped firmly at the upper end in a

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* Messrs. Seaton and Jude, "Impact Tests." Inst. Mech. Eng., 1904.

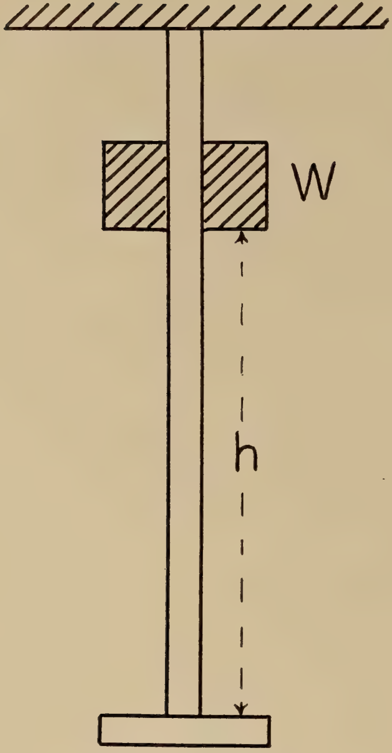

FIG. 1.—VERTICAL DROP TEST

block, which can slide up or down on vertical pillars. At the lower end of the specimen (which is not gripped in the block) there is fastened a heavy lump of metal. The grip, the specimen and the weight are lifted up to a known height, by sliding them up the vertical pillars. They are then permitted to fall. When the block which holds the top end of the specimen has fallen a certain prearranged amount, it is suddenly arrested by a stop, which is fixed to the supporting pillars. The weight on the lower end of the specimen is still unsupported.

The weight and the height through which it falls, have been previously so arranged that the kinetic energy of the weight is sufficient to rupture the specimen; of course, the weight must have more than enough energy to *just* break the test piece, otherwise it would possibly fail to cause fracture. It is, therefore, necessary to know the energy of the weight immediately after the material is broken. The exact energy of the weight just before rupture may easily be calculated. The difference between the energy of the weight just before and just after fracture is, therefore, the energy absorbed by the material.

### AN ACTUAL MACHINE

Exactly on the same principle, with ingenious details added, was the machine used by Messrs. Blount, Kirkaldy and Sankey.* The specimens tested by it are 0.357 inch in diameter and the available drop is 40 feet. [This is possible only because the late Mr. Kirkaldy, who designed the well-known testing building in Southwark, made special provision for trap-doors, a really remarkable instance of foresight].

A diagram of the essential parts of this apparatus is shown in Fig. 2. The anvil *A* is very rigid and heavy. It is made up of two castings, each of which weighs 400 pounds, securely fixed on to rolled steel joists *B B*, the latter being embedded in concrete. The effective weight of the whole apparatus is 2,000 pounds. This anvil is used for arresting the progress of the specimen *c*, the "top"—or weight *D*—and the grip *E*. When fracture takes place the weight continues to fall. The value of the weight can be varied easily from 10 pounds to 20 pounds.

The system of measuring the energy in the weight after fracture is a noticeable feature of the apparatus. It is done by means of electric contacts. These are arranged so as to momentarily interrupt the current at the definite periods during a test.

The first break of the contacts is at the moment of release and is operated by a thread, attached to the crosshead, which opens the switch *F*. The second occurs at *G* when the anvil is struck. The third is at *H* after the tup has fallen 10 feet below the position at the instant of fracture. All three switches work very freely and are closed again by springs immediately after they are opened.

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* "Comparison of the Tensile, Impact Tensile and Repeated Bending Methods of Testing Steel." Proc. Inst. Mech. Eng., 1910.

There is a Morse telegraph "inker," a pendulum half-second contact maker and a vibrating tuning fork. When the electric contacts are made and broken the usual chronographic method is worked. Therefore, the times between the standard points mentioned above can be ascertained with great accuracy. A check upon readings is afforded by the record of times between the first and second points mentioned above. The time between fracture and the third contact is used to calculate the energy in the top after fracture. Details of actual calculations can be obtained by reference to the original paper.

A few notes on the experiments made may be of interest. The energy absorbed, per cubic inch, in a test with the machine, when divided by the elongation, gives a measure of the breaking stress for an ordinary tensile static test. The strength, as found in this manner, from the impact test averaged 1.2 times that given by a static test. The energy necessary to rupture a piece of material during a static test can easily be calculated, but it is not usual to do so.

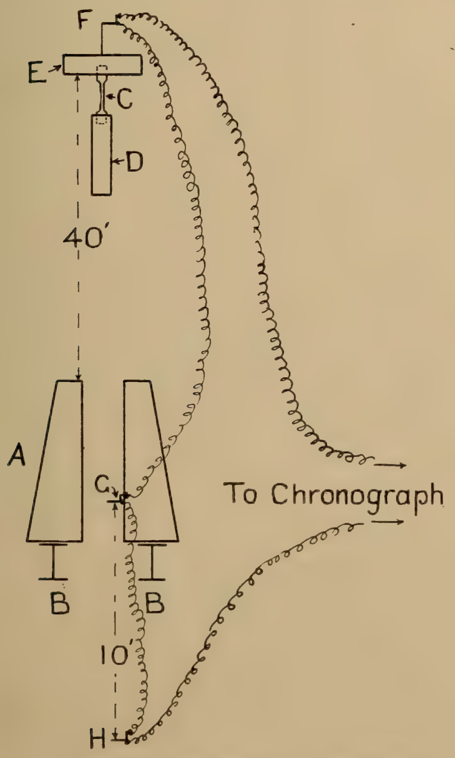


FIG. 2.—THE BLOUNT, KIRKALDY AND SANKEY IMPACT TESTING MACHINE

Sir Alexander Kennedy suggested that, on assumption that the top of the stress-strain diagram is parabolic in form, the energy used per cubic inch of material is equal to:

$$\frac{\text{Elongation}}{\text{Gauge length}}\left\{\frac{2\text{ breaking stress}+\text{yield point}}{3}\right\}$$

The object of any mechanical test on steel is to obtain information as to strength and ductility. The impact-tensile test gives both elongation and contraction of area. It is, however, a fact that in the experiments mentioned above, the figures for these points are greater than those obtained with static-tensile tests. It is thought probable that the explanation is that the breaking effort is sudden and produces more general extension.

The most unsatisfactory point revealed by the tensile-impact test is that the energy per cubic inch does not vary greatly with the different types of steel and is, therefore, no definite criterion of the type of steel. On the other hand, it has been established beyond question that normal good steel will withstand a tensile-impact test as well as the customary so-called static test. If, therefore, an inexpensive and reliable machine for such tests could be devised it would be a step in advance. The ordinary tensile testing machine costs far too much—and yet, it is not easy to see how to reduce the initial outlay.

A suggestion was once made to the writer that centrifugal force might be used to fracture a specimen in tension. The size of the machine would be small and no foundations would be required, but the idea seems impracticable because of the energy absorbed by windage.

### THE WOOLWICH POLYTECHNIC MACHINE

An impact tensile testing machine designed by Mr. D. R. Mac Lachlan, B. Sc., A. M., Inst. C. E., to whom the author is indebted for the details mentioned below, has recently been installed at the Woolwich Polytechnic.

In this machine (shown diagrammatically in Fig. 3) the specimen *A* is rigidly held at its upper end and carries at the other end a platform *B*, on to which a weight *C* is dropped from a prearranged height, precautions being taken to prevent the occurrence of bending effects.

An interesting feature of this apparatus is the method by which the velocity of the tup, during both its fall and the fracture of the specimen, is automatically recorded.

At the side of the machine is fixed a drum *D*, 15 inches long by 4 inches diameter, which is rotated at 750 revolutions per minute. The drum is covered with smoked paper, on which a line is traced by a marker *E*, attached to the tup. A trip gear (not shown in the diagram) causes the point of the marker to come in contact with the paper as soon as the tup falls below the level of the top of the drum. The same arrangement withdraws the marker from the paper before the rebound of the weight.

During the fall of the tup, in addition to the curve traced by the marker, a series of vibrations, each lasting one-fiftieth of a second, is recorded on the smoked surface. From the data thus obtained the velocity and kinetic energy of the tup, both before and after breaking the specimen, are calculated.

An alternative method of measuring the final kinetic energy of the tup is provided and takes the form of an air cylinder *F*, fitted with a piston *G*, on which the tup falls. The rise of pressure in the cylinder is measured on a pressure gauge and from it the final kinetic energy of the tup may be found. In order to obtain calibration curves connecting kinetic energy and pressure the weight is allowed to fall from various heights on to the top of the piston (without breaking a specimen) and the rise of pressure noted each time.

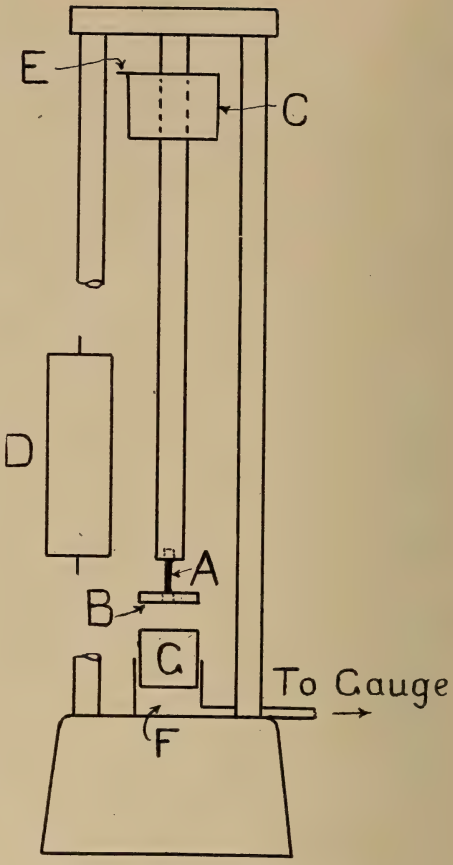


FIG. 3.—THE MAC LACHLAN MACHINE

As some of the energy of the falling tup is absorbed in friction with the guides, the first method of measuring initial and final kinetic energy is the more accurate, as in it the actual velocities are recorded.

### (2) TRANSVERSE IMPACT-TESTING MACHINES

*Izod's Impact Machine* (Fig. 4)—This apparatus consists of two A-frames on which a braced pendulum

*B* swings. The bob of the pendulum consists of a cast iron head *A*, which carries a knife edge *R*. The specimen *S* takes the form of a notched bar whose section is ⅜ inches by 5⁄16 inches (Fig. 7), and is firmly held in a vertical position in a vise *T*. The pendulum is raised to a height sufficient to break the specimen and is then let fall. The rod of the pendulum is prolonged above the bearings as shown at *E* and serves to operate two pointers *P* and *Q* which indicate on the scale *J* the initial and final kinetic energy of the bob in foot-pounds. The energy expended in breaking the test piece is the difference of the two readings. The maximum capacity of the machine is 23 foot-pounds.

### THE NATIONAL PHYSICAL LABORATORY APPARATUS

The impact-testing machine at the National Laboratory tests notched specimens 5 inches long by ⅜ inch square by breaking them transversely. The specimen A has its ends supported by knife edges *B B*, fixed to the bosses *C C*, which are, in turn, held in a suspended anvil *D* weighing 60 pounds. The span of the knife edges may be adjusted by moving the bosses *C C*. The tup *E*, which weighs 47 pounds, is also suspended and is provided with a knife edge *F* for the purpose of applying an impact load to the centre of the test-bar. The suspensions of the anvil and the tup are arranged in such a manner that, when both are hanging freely, the knife edge on the tup just touches the centre of the specimen.

In carrying out an experiment the tup is swung back to a sufficient height to break the specimen at one blow, and then released. Part of the energy of the tup is expended in breaking the specimen and the rest raises the tup and the anvil to heights which are both observed. Knowing the initial height of the tup and the heights to which the tup and the anvil swing after fracture, the energy absorbed in breaking the specimen can be found.

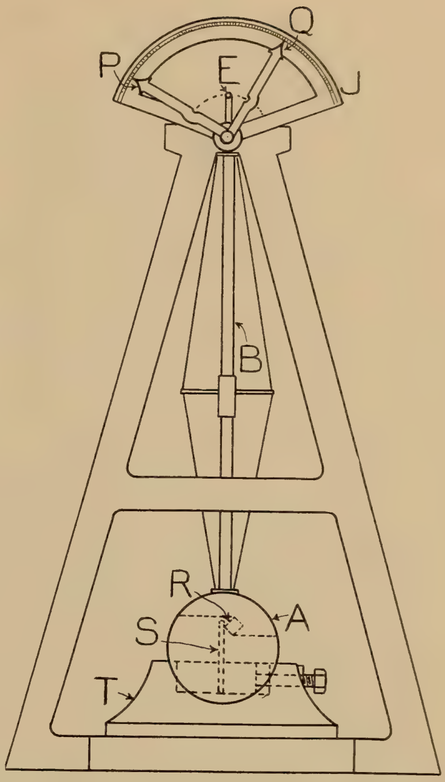


FIG. 4.—IZOD'S MACHINE FOR TRANSVERSE TESTING

### SEATON AND JUDE'S MACHINE

This machine differs from those already considered, in that the specimen is not broken at the first blow, but by a succession of blows applied first on one side and then on the other.

A tup, weighing 7 pounds, is repeatedly raised and allowed to fall through a height of 2 feet on to the centre of a notched specimen 4 inches long by ½ inch square, supported on a 3-inch span. After each blow the specimen is turned over until fracture occurs. The number of blows required to break it is taken as a measure of the ability of the material to withstand shock.

### AN IMPROVED FORM

of this type of machine, designed

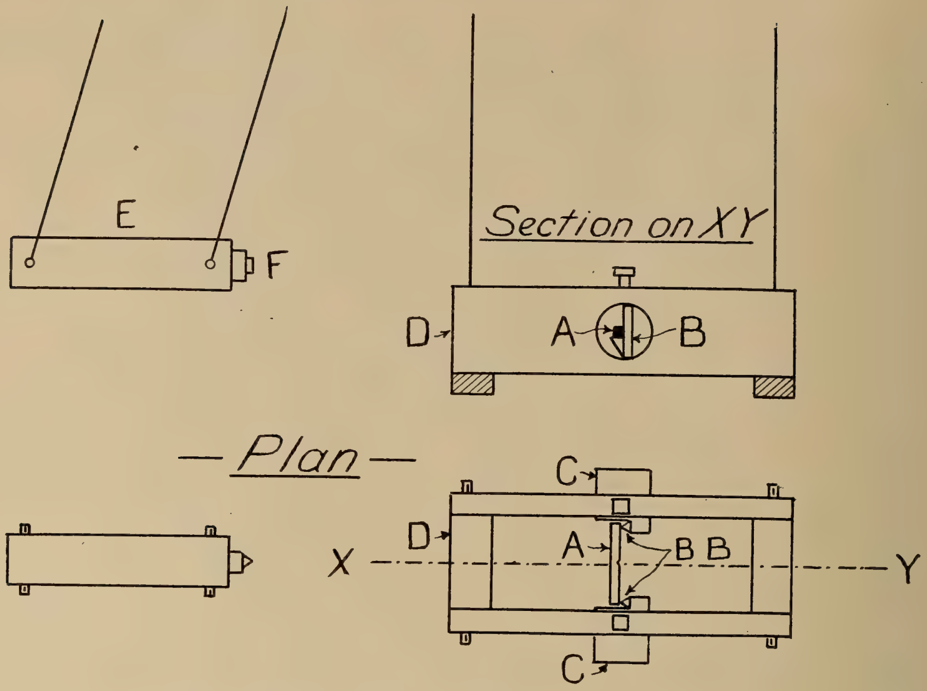


FIG. 5.—APPARATUS USED AT THE NATIONAL PHYSICAL LABORATORY

originally by Dr. Stanton, is shown. (See Fig. 6).

The tup *A* is fixed on the end of a long arm pivoted at B and is repeatedly raised and allowed to fall by means of the lever *M* actuated by the crank J. The specimen *D,* which consists of a round bar 4 inches long by ½ inch diameter, with a groove turned in it at the centre, is held in a chuck in such a way that it is supported on knife edges 3 inches apart, and is subjected to an impact load each time the hammer falls. Between successive blows the specimen is turned through 180 degrees, so that it is first bent in one direction and then in the other. The arrangement for rotating the test-piece is shown diagramatically, but as a matter of fact, the specimen itself does not revolve continuously. After receiving a blow it is suddenly turned over and then remains at rest until after the next blow has been delivered, when the process is repeated. This is accomplished by means of a mechanism (not shown in the diagram) between the pulley *F* and the chuck.

The machine gives 100 blows per minute and is driven by an electric motor. A revolution counter gives the total number of blows struck, as, on fracture, the hammer in falling opens a switch, placed below the specimen, and shuts down the motor.

## COMPARISON OF THE TWO MAIN TYPES OF IMPACT-FEEDING MACHINES

We have seen that the tensile-impact-tester usually takes plain, round specimens, while the transverse-testing machine must be used with notched test pieces. At the present time the relative merits of these two types of test piece form the subject of a great deal of discussion.

The simplest form of impact-testing machine is undoubtedly the pendulum type, as with these machines the energy expended on the specimen is easily computed, by observing the initial and final heights of the suspended portions of the apparatus.

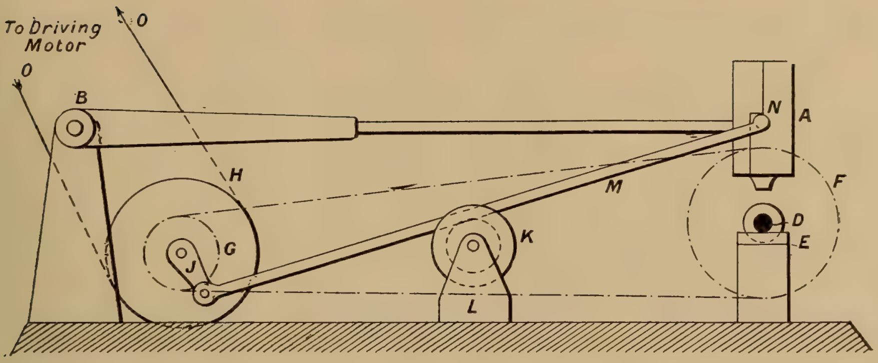


FIG. 6.—DR. STANTON'S IMPACT MACHINE

Transverse tests are essential for this type of machine, so for this reason the test pieces must be notched to ensure that fracture occurs at a definite point. If plain specimens were used the distance between the point of fracture and the applied load would vary for different specimens and would affect the results. The great disadvantage of notched specimens is that the slightest weakness in the microstructure of the metal at the bottom of the notch seriously affects the strength of the test piece. The sharpness or otherwise of the angle of the notch produces marked variations.

Tests carried out on plain specimens appear to be the most scientific, but in this case the disadvantage lies, to a great extent, with the constructional difficulties of the machine. Machines of this type have to be capable of dropping the tup from a great height and also have to be provided with some arrangement for measuring the final kinetic energy. Obviously a tensile impact machine is more expensive to construct and more difficult to use than one of the pendulum type.

In the case of a machine which requires notched specimens, those of the Charpy type, recommended by the German Association for Testing Materials, seem likely to give the most consistent results. The construction of this form of bar is shown in Fig. 7, from which it will be noticed that the hole is drilled in such a position that the thickness of the specimen at the notch is reduced to one-half of its original thickness. The standard V-notched specimen for use in Izod's impact machine is also illustrated.

### FUTURE INVESTIGATIONS

As testing by impact is a comparatively recent innovation, it follows that there is still a great deal to be found out about it.

For instance, although it is known that temperature has an important effect on tests (because metals rapidly become more brittle with a decrease of temperature, and so require less energy for fracture), definite data are wanting and will have to be found by a thorough experimental investigation.

Another feature, about which little

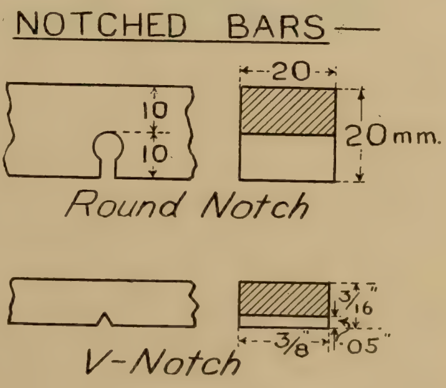


FIG. 7.—VARIETIES OF NOTCHED BARS

is known, is that of time effect on the energy expended in fracturing the test piece.

It appears at first sight rather ridiculous to speak of time effect in impact tests, as the material is broken almost instantaneously. It is obvious, however, that a small weight falling from a considerable height will fracture a specimen in less time than will double the weight falling from half the height.

Also, even when tested under identical conditions as to weight of tup and height of fall, a weak specimen will be broken in less time than a stronger one (assuming the same elongation), as in the former case the velocity of the tup, both during and after fracture, is greater.

Whether the time of fracture has any effect on the energy absorbed or no it is not at present clear and will doubtless form the subject of an experimental investigation in the near future.

We may sum up the present state of affairs by saying (1) that the value of the impact test is fully appreciated; (2) that for ordinary commercial work it is used to supplement, but not replace, the static tensile test; (3) the test with a notched bar is easier to make than a tensile-impact test; (4) that the ordinary objections to a V-notched specimen are not applicable to the specimen with a round notch; (5) comparative results with different machines are difficult, because of "time effect"; (6) there is still plenty of work to be done by investigators in this matter.

# CONTINUOUS VERTICAL TRANSPORTATION

By J. F. Springer

THERE can be no doubt but that there is in the industrial world a distinct tendency in the direction of *continuity*. In fact, our modern civilization has been greatly modified by the continuous production made possible by the rolling mill. At what price would steel railway rails be sold if they had to be produced by some non-continuous process? What would be the cost of the modern steel frame sky-scraper if it were impossible to produce the structural shapes by the continuous procedure of the rolling mill? This device affords a means of continuous forging. The automatic lathe is a good example of the modern tendency towards continuous production. The stock is automatically fed in through the spindle in the form of long bars. When a piece of work has been finished, this bar is advanced a suitable distance and the next piece is formed. We have here an approach to continuity: a great part of the time otherwise lost in releasing the finished piece and chucking the new blank is now saved. We are beginning to get awake to the very considerable losses involved in interruptions. And yet in the history of writing we can discern a very distinct tendency to avoid them. Palæography tells us that the first Greek manuscripts, for example, were written in capital or uncial letters. These were made separate from each other. It must have been realized, however, that much time was lost in lifting the writing instrument and bringing it into position again between letters, for the later manuscripts are commonly written with letters connected. To come back to common, every-day life, railway transportation men perceive pretty clearly the enormous loss incurred in frequent stops of the passenger train. There is the time lost while the train is actually quiescent. To this must be added the time lost in slowing down and getting under way. A good example is found by comparing the times occupied by local and express trains of the New York Subway between Brooklyn Bridge and Ninety-sixth street. The distance is about 6 miles, and the two classes of trains have about the same maximum speed. Taking the number of stops for the expresses as four, and for the locals as twenty, we find that this excess of sixteen stops introduces a time-loss of ten minutes. The expresses make the trip in seventeen minutes; the locals in twenty-seven. The loss is about 59 per cent., or about 3.7 per cent. for each additional station. But the interruption of the motion of the train is, perhaps, not so important as the interruption in the continuity of the train itself. If there were no intervals between trains there would be an enormous increase of the capacity of transportation. So great would this increase be that the continuous train could be run fairly slow and yet be able to carry the traffic. The individual might require a longer time on the train, but there would be a rapid movement of the whole mass. No one would have to wait for a train; there would be no stops; there would be no slow-downs, no gradual starts. Such a train, if possible, would solve New York's rush problem—the problem of getting a very great mass of people to their destinations in a short period.

Now this is just the problem that

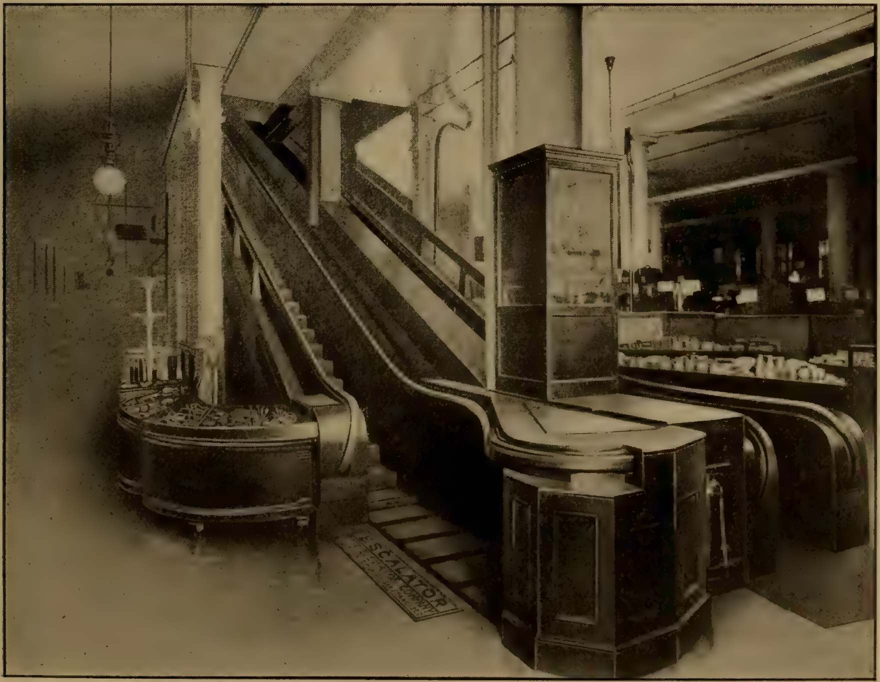
needs solution in many situations. For example, a great multitude of people are discharged in a short period of time at a great railway terminal. The track level may be considerably below the street. The problem here is not so much that of getting a few individuals up to the street in a very short interval as it is that of getting them all thither in a reasonably short period. Elevators are inadequate to the solution. The happy passengers who succeed in getting on board are quickly brought up—the rest must wait. Many will have to wait an unreasonable time. The only solution is by some *continuous* method. A very wide stairway or inclined plane would afford facilities. But the modern passenger is not inclined to look with favour on making a long climb, especially if he is encumbered with hand luggage. He does not want to supply the power to complete his journey. A continuous mechanical means of transportation is the only solution which can be expected to meet all requirements. Again, a department store desires to get multitudes of people onto its upper floors. Elevators constitute the usual solution of this problem. But it may well be doubted whether the solution is really adequate. In one large department store in New York there are more than thirty elevators. And the matter is dealt with similarly in other stores. The present distribution of the various departments may, perhaps, be pretty well accommodated. However, it is not to be denied that there is a distinct tendency in such stores to crowd all the departments that receive many visitors upon the lower floors. In other words, the distribution is governed by the capability of the elevators to make the various floors accessible to large numbers of people. The problem in the department store is entirely different from that in an office building. In the office building it is only a moderate number of people who desire to reach the various floors within moderate intervals of time. The elevator has solved this problem, and solved it very successfully. The great buildings in New York, Chicago and other similar American cities, with their fifteen to forty-four floors, are magnificently served. There is no especial inequality in the desirability of the various floors. The tenth floor is just about as desirable as the fifth or third. It is the elevator that has equalized the various levels. But the elevator has not succeeded in doing for the department store what it has done for the tall office building. In the latter all that is necessary is the fairly rapid circulation of a moderate stream of people. In the department store a great stream has to be handled. This distinction should be noted well. What it needs in order to give its various floors an accessibility that has some approach to equality is a *continuous* means of vertical transportation.

A rather novel method of accomplishing the desired results is through the agency of the moving stairway, or *escalator*. In general appearance, this is a staircase, and may be used as such. Upon closer inspection, however, the steps will be seen to be moving onward and upward. A person who uses the stairway in the ordinary manner will be, accordingly, carried up and on in addition to the movement due to his own exertions. He thus gets up the steps at quite a rapid rate—much as if he went up running, two steps at a time. But if he is not in such a hurry the escalator will itself do the entire service. He has only to stand upon the tread of one of the steps to be carried along. Now if one notices a little more closely, he will see that even an instantaneous view would show some divergence from the customary staircase. The first few steps at the bottom have less than the standard height. And a like remark applies to the final steps at the top. However, at all times and everywhere the steps have standard treads. There is never any variation in this respect.

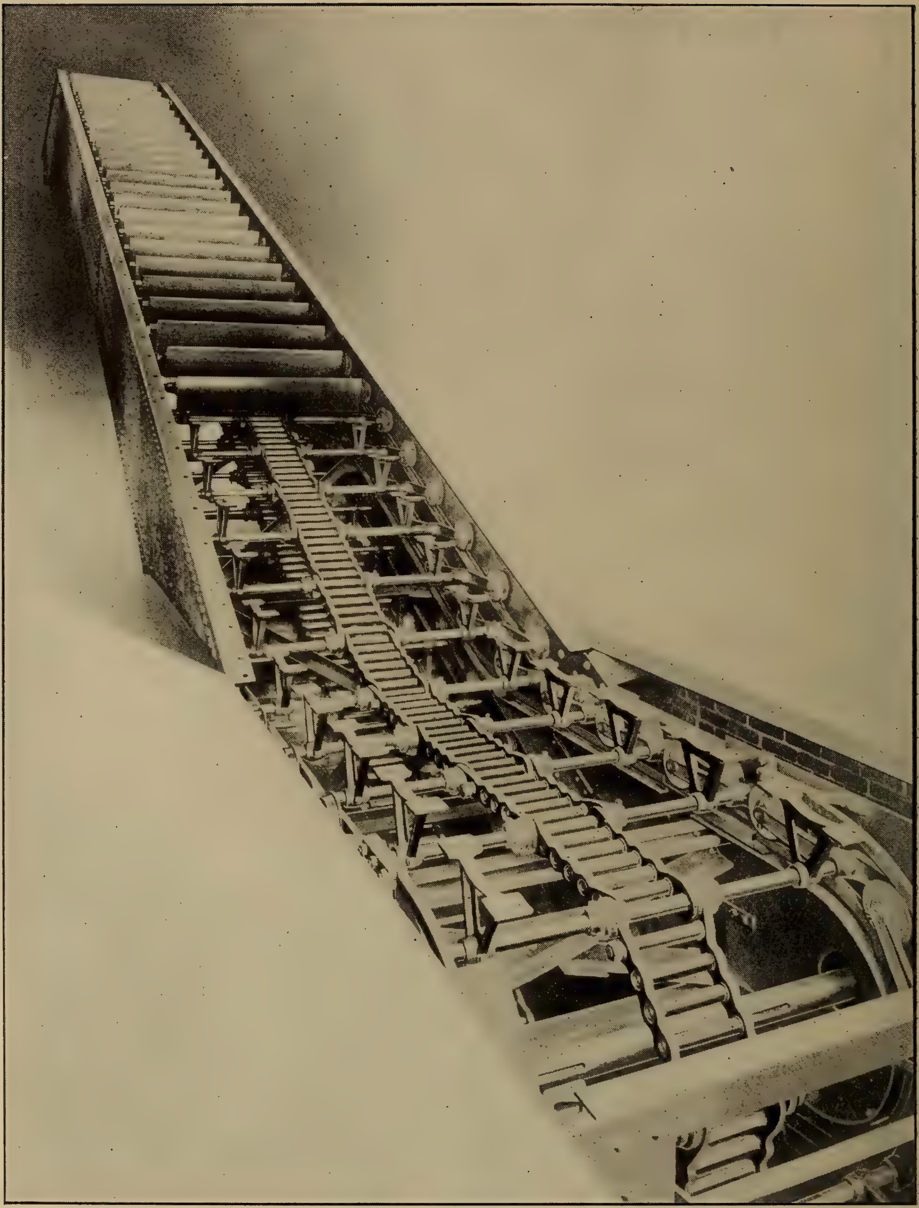
At the bottom, just in front of the lowest step, a series of treads is to be seen moving towards the stairway. These fit closely together and furnish a level, uninterrupted surface. It is upon this moving platform that the passenger steps. As the forward movement is at a less rate than that at which one ordinarily walks—being, in fact, only about one-third as rapid—there is no sudden jar. It is very easy to step on—ladies and little children are quite equal to the task. As one stands upon one of the treads he soon finds that it begins to rise, at first very slowly and then more rapidly, until there is a vertical distance of 8 inches between it and the tread just behind. This relation is strictly maintained up the whole staircase until one reaches the very top, when the step upon which one stands falls off in its rate of rise. The step to the rear consequently gains upon it. In another moment it ceases entirely to rise and preserves only a horizontal forward movement. It has, in fact, joined a number of its fellows ahead to form a moving platform. What has occurred at the top is merely the reverse of what took place at the bottom. In respect to the relative movement between contacting parts of consecutive steps, the adjustments and forms are such as to avoid a tendency to grasp small articles or clothing. The one surface merely slips slowly past the other, the joint being very minute.

The moving steps at their ends slide next the smooth surfaces of the wooden wall which forms a kind of balustrade. The joints here are also very perfect, and for similar reasons. To secure such results requires merely perfection of workmanship, and this it is very possible to get.

It is very important that the escalator be constructed with accuracy and skill both within and without. The escalator is indeed a conveyor, but it is more. It must be an evenly-running piece of mechanism. This



ESCALATOR IN A DEPARTMENT STORE

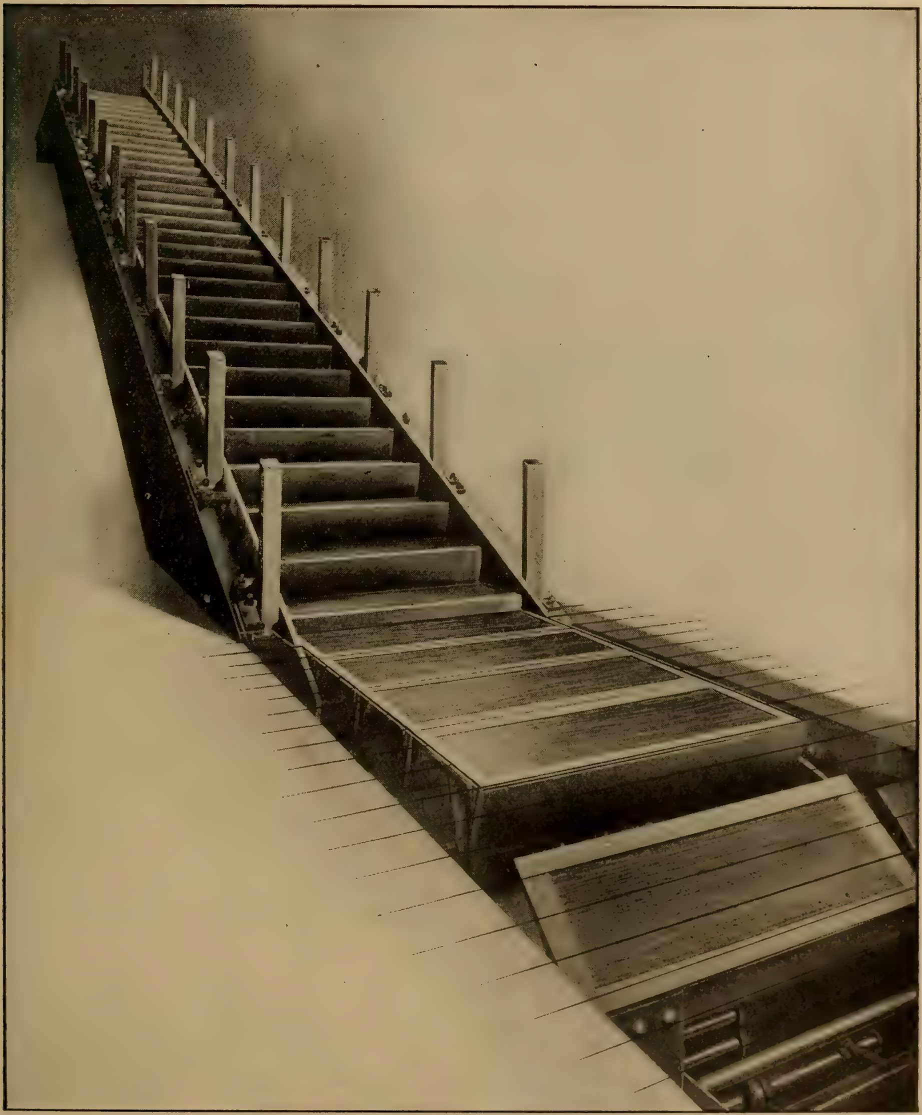


THIS SHOWS THE MECHANICAL DETAILS OF AN ESCALATOR

calls for great perfection of workmanship, particularly with regard to the chain by which it is driven. In order to maintain stability and exact horizontality of the steps, a number of important dimensions must be kept very close to standard.

The method of insuring the proper movement of the steps is quite interesting. In the first place, all the steps are strung together to form an endless chain. One-half or more is always out of sight. Each step is carried on four wheels, two at each end. The wheelbase from front to back is 6 inches longer than the tread. The object of this is to secure great stability. Some such provision is necessary, because the load on a tread is very liable to unsymmetrical distribution. Especially on the incline the four wheels are each provided with what is in effect a separate rail. The rails corresponding to the forward wheels of a step are situated ahead of those corresponding to the rear wheels. This is a necessary provision to enable the wheelbase to be supported while maintaining a horizontal position. In the vicinity of the landings all rails are about at the same level.

When once the various parts of a step, including the truck, are assembled, it is, apart from the wheels themselves, a rigid whole. There is a horizontal arm which carries the two wheels at the end of a step, but the forward and rear part of this arm are in different vertical planes. The



AN ESCALATOR PARTLY CONSTRUCTED

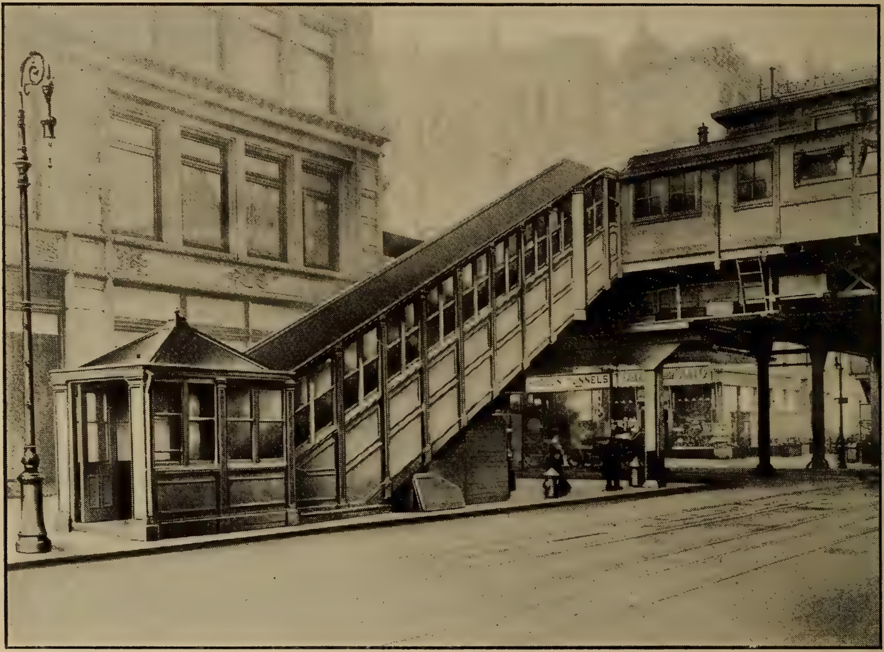
short moving platforms at top and bottom, together with the intermediate stairway, really constitute a train of flat cars continually disappearing at one end and continually reappearing at the other. The passenger stands on one of the cars; or, if he chooses, he may step from one to the other. This important fact marks the escalator off from every other system. At no time does the surface on which the passenger stands change its relationship to his body.

At the bottom, the moving platform is made flush, or nearly so, with the floor. At the upper end, the moving platform must, of course, disappear, and the passenger must get off. A shunt, V-shaped in plan, or simply a transverse barrier arranged at an angle, is provided. At the bottom of the shunt surface a moving band is arranged. Its movement is in the same general direction as that of the platform, so that the two combine to carry off of the escalator any article which comes into contact with band and platform.

One who stands near either end of a step will, naturally, rest his hand upon the rail. The upper surface of this is so arranged that it moves along at the same rate as the passenger, and thus provides a support which travels with him.

In fact, the whole escalator proposition with reference to the comfort and convenience of the passenger has been thoroughly worked out. Little children, ladies, old men—all can safely get on, find comfortable transportation, and safely get off. One who is seriously crippled would, perhaps, better take other means. The normal individual will have no difficulty, as anyone may see who will stand at the upper end of an escalator and watch the passengers get off.

An ordinary speed is 90 feet per minute. This is a horizontal rate, and is to be taken to mean that 90 linear feet of platform are delivered per minute at the upper end of the escalator. Now, each tread is 1½ feet from front to rear, so that we



AN ESCALATOR SERVING AN ELEVATED RAILWAY STATION IN NEW YORK

THE ESCALATOR AT THE PENNSYLVANIA STATION, NEW YORK, THIRTY-FOURTH STREET SIDE

actually have the delivery of one tread per second. If the escalator is 5 feet wide, three passengers can be comfortably accommodated upon each tread.

If this is true as relates to externals, it is, perhaps, as much so when we come to consider the internal construction. An escalator is, indeed, a conveyor. But it is rather more. Absolute stability of every step must be maintained. This must be done, not merely on the level and on the main portion of the incline, but also at the transition points above and below.

One of the first escalators ever erected was the one used at the Paris Exposition in 1900. Many thousands of people were successfully transported by this early machine—people of a very miscellaneous character, too. The first year of public use witnessed the escalator under the trying conditions involved in the transportation of such people as visit an international exposition, a popular department store and an elevated railway. The escalator installation in the main building of the Greenhut-Siegel-Cooper store, in New York, has been in operation for eight or ten years, as has also the escalator in the Gimbel store, in Philadelphia. This last escalator is the same machine that was used in Paris. In the Macy department store, in New York, is a battery of escalators connecting five floors. In Boston, at the Henry Siegel store, there is an equipment consisting of ten escalators. These connect in both directions the basement and the five floors above it. In Chicago, the Boston Store is equipped with seven escalators, four up-going and three down-going. In New York, in addition to cases already cited, escalators are installed at the Thirty-third street station of the Sixth Avenue Elevated Railroad and at the Manhattan street station of the Subway on Broadway. In this latter case the equipment includes a duplex escalator. Also there is a large ascending escalator at the new and magnificent station of the Pennsylvania Railroad on Seventh avenue. This machine connects an underground level with that of the street on the Thirty-fourth street side. It is easy to note the comparative popularity as between the escalator and the stairway at some of these installations. Thus, at Manhattan street and Broadway the stairway is but little used; the escalators are the real means of passing between levels. Again, at the Pennsylvania station there is a stairway alongside the escalator; the stairway is wellnigh deserted. Exhaustive and accurate counts are said to have been made which show that 98 per cent. of the persons passing out through the exit make use of the escalator. A very important installation of escalator equipment, as showing the beginning of a new tendency, is at the Wood Worsted Mill, at Lawrence, Mass. This mill is six stories high, 1,500 feet long, has a floor area of nearly 60 acres, and employs 6,000 men and girls. It is, in fact, the largest worsted mill in the world. Here eight escalators, divided into two batteries of four machines each, have been introduced. The one battery serves the third and fifth floors, the other the fourth and sixth. The only time when these machines are in strong demand is at morning, noon and at the close of the working day. As they can be reversed in direction of movement, the very same machines are used to take the crowd up at the beginning of the two half-days and down at their close. The escalator is built by the Otis Elevator Company 17 Battery place, New York City.

The firm installation at the great Wood worsted mill, just referred to, is to be justified not merely on humanitarian lines. It is a humane thing. The employees using the escalators now reach their looms on the higher floors in good physical condition. Instead of lagging at the beginning, they are ready for a prompt resumption of their work. A little reflection should convince one that it really is a matter of consid-

ESCALATORS AT THE WOOD WORSTED MILL, LAWRENCE, MASS., BEING OPERATED IN BOTH DIRECTIONS erable importance whether a large number of operators begin work in a fatigued condition or not. The escalators installed at this magnificent mill involved an outlay of capital, of course; but the president of the concern thinks it is justified from an economical standpoint, because of the increased value of the service obtainable from the employees. Further, it is thought that the mill with escalators has an advantage in busy times because of the preference in the minds of the work people. Such a mill would have the pick of them. There are many factories and mills throughout the country where the number of employees and the character of the buildings are such that the use of adequate means of vertical transportation would show distinct results in the way of increased quantity and bettered quality of output. In any individual case the economic advantage would manifestly be small. But where it is a question of several thousand operatives every day, the modest amount realized from each would soon swell into a considerable sum. Against this must, of course, be charged the interest on first cost, depreciation, operation, etc. The corporation operating the Wood worsted mill thinks that the balance is on the right side; and this opinion is worthy of consideration.

The ability of the escalator to carry a great many people turns on the fact that it is absolutely continuous in operation. There are no slowdowns, no gradual starts, no stops at the various floors. Like Tennyson's brook, it flows on forever. The passengers get on and off while it is in motion.

It would seem probable that the near future would witness the introduction of some adequate mechanical means for the vertical, and at times horizontal, transportation of arriving and departing passengers at many of the larger railway stations. There is a distinct tendency to abolish station tracks at grade, in some cases to introduce more than a single sub-level. One example of the underground station track is at the Pennsylvania station in New York, as already noted. Another should be at the new terminal under construction by the New York Central Railroad in New York.

The London Electric Railway is about to install two escalators at Earl's Court Station. One will be for the accommodation of passengers ascending from the tracks to the street; the other for those desiring to descend to the trains. The difference in level is here about 38 feet. This vertical distance will be covered in either direction in about one minute. Estimating the capacity of each escalator at no more than 9,000 per hour, it will be possible for 150 people discharged from a train to make the trip from the one level to the other in about two minutes. That is to say, only about this length of time will be required from the moment the first passenger boards the escalator until the last one is brought to the street.

In all such cases there should, of course, be adequate mechanical means for reaching the street level—means capable of handling large crowds expeditiously, safely, comfortably, and at reasonable expense to the railway.

# THE CONDENSATION OF STEAM

By W. H. Booth

IT is only within comparatively recent years that much attention has been given to the question of the condenser in land work. Previously most land condensers were of the jet variety, and the jet condenser has none of the difficulties which hamper the surface condenser. There are no tubes to be blanked or choked by hot films of water, and there are no obstructions in the way of the flow of steam to the nearest cold surface. Many papers have appeared on surface condensers during the past few years, and these have probably been due to the fact that the land condenser does not get that supply of cooling water which flows so easily to the marine condenser. One such paper was recently presented by Mr. W. A. Dexter before the Manchester Association of Engineers. It is, generally, a resumé of condenser practice, and the chief point, which appears somewhat novel, is the author's recommendation that the body of a condenser should taper gradually narrower along the downward path of the steam, for the reason that the steam velocity should be equally rapid throughout, in order to sweep the water off the tube surfaces, and that such velocity is only to be secured by narrowing the condenser as the steam disappears. This seems rational, though it prevents the division of the tubes into separately drained sections, and so fails of an important aid to efficiency, unless the steam is made to travel laterally to and fro. This the author rejects, preferring a direct forward movement of the steam.

But the author and most other writers do not appear to take into consideration the kinetic theory of gases when they think about the process of condensation. In this theory steam is not regarded as a mass of homogeneous nature, but merely as a fortuitous aggregation of atoms, all endowed by heat with the power of automatic movement. Each molecule darts hither and thither and collides with its fellows. Obviously the path of a molecule is very short, and the velocity is very high—probably 1,800 feet per second. In a mass of extreme tenuity the path of the molecules becomes longer, and, with very low temperatures and good condensation, a space may become nearly vacuous and the number of molecules comparatively few. Let us assume a space one yard cube in which the vacuum is so perfect that each molecule has the chance of a free run of 1 foot. In attempting to cross such a box the molecule would travel a foot and cannon against another molecule and dart off in another direction. Every molecule which happened so to be placed that it started on the move towards one of the walls of the box not 1 foot distant would probably reach that wall, and if that wall was cold the molecule would stick to it as water, for it would part with its heat to the wall and lose its power to rebound. Now, no matter how many molecules are present, they are all seeking the cold surfaces at a velocity of 1,800 feet per second, and if the surfaces really are cold it will not take long for every molecule to reach a cold surface. That this is so is amply proved by the very slight to-and-fro swing of the finger of a vacuum gauge on a condenser into which a big cylinder is exhausting many times a minute. The finger indicates each stroke of the engine, but it also indicates the extreme rapidity with which each volume of steam drops from release pressure to vacuum pressure of one to three pounds. Undoubtedly most of the steam is condensed against the first row of tubes. This first row must be covered with hot water—so hot that the tube ceases seriously to condense more steam. The tube surface becomes a rebounding surface, whence the steam molecules now recoil and try to get back to the cylinder, but the oncoming torrent of steam drives them forward upon and between the condenser tubes. Through the narrow spaces the steam is worried forward, and the molecules find their way to cold tubes further on. But the first row of tubes affords such a rebounding surface that there is set up what is known as back pressure in the cylinder. It would be possible, by means of a series of delicate pressure gauges, to find the pressures at any number of points along the path of the steam. Clearly what is required is either a much larger area of first tubes, so as to kill the steam more promptly, or a larger area of openings between the tubes, so as to admit more of the steam to colder tubes further on. The better to distribute the steam over the tubes, it ought to enter a condenser in a direction parallel with the tubes by way of a hood tapering to nothing at the end of the tubes furthest from the entry. Such a hood lays the steam all along the first layer of tubes and prevents air-blinding, and gets the fullest duty out of all tubes. But this is not enough. It is probably better practice to provide passageways for steam than to block its way with tubes. Let us suppose a first row of forty tubes produces a back pressure of two pounds. Remove four-fifths of the tubes and the remaining eight would produce, let us say, only half a pound back pressure. In the second row leave 10 tubes, in the third row 13, in the fourth 20, and in the fifth 30. Thus in five rows there are 81 tubes, in place of 80 in two rows, and the five rows have condensed as much steam as the former two rows and produced only a fourth, or perhaps, only a fifth, of the back pressure. So much of the steam will now have gone that probably the remainder could be dealt with by ordinary spacing beyond the fifth row. Most condenser makers remove wedge-shaped masses of tube surface already, so as to provide better access of steam to the inner mass of tube surface, but this does not seem enough: it does not seem to recognize sufficiently the kinetic theory on which the flow of steam depends. Ideally, the best condenser is that in which all the cold surface is arranged in the bounding walls, and the volume is larger. There is a very minute fraction of a second every molecule will reach a cold surface. Tubular condensers are merely concessions to commercial spaces, and there is little doubt that closely spaced tubes are a concession to the limited spaces of a ship rather than a commercial necessity. Land conditions do not demand such small-bodied condensers. There is no *raison d'etre* for them, for the cast-iron outer case is not a costly item and no more tube surface need be given. Given engine-room space, it is a mistake to crowd too many tubes into a given casing. Land practice cannot do this with the same disregard as can marine practice, for at sea there is generally any amount of cold water to keep the tubes so cold that the first row can kill a large portion of steam. The whole subject can best be thought out if the kinetic theory of gases be used as a guide to thought.

# TECHNICAL LITERATURE

**By F. Ashley**

PERHAPS few engineers actively engaged in practical work appreciate the rapidity with which technical literature is poured upon the market each year. Books on all kinds of engineering and scientific subjects are constantly being written, but it is a regrettable fact that few possess any real merit, and it is not at all easy to see what useful purpose many are intended to serve. Technical writers may be divided into two classes—those equipped with a special knowledge of some particular branch of engineering or science, but devoid of practice in writing, and those having a general technical knowledge and equipped with the power of putting things on paper. Of these, the latter class of author is sometimes to be preferred; for, although he may not have a deep knowledge of any particular subject, his ability to express himself clearly enables him to turn out readable and sometimes useful work. One of the principal qualifications of a successful technical writer is his ability to collect information, and, provided that he has a fair general knowledge of his subject, he will know what he should obtain, and, having got it, how to put it into suitable form for publication.

The specialist, on the other hand, writing on his own particular subject, not infrequently ignores the value of information which may be obtained from outside sources and sets forth that only which has been brought to him by practical experience. Were it not for the fact that only a few practical engineers have the ability to put down their knowledge in a readable and intelligent manner, the work of those who only occasionally become authors might prove valuable; but, as it is, the literary work of practical men is frequently dry and absolutely uninteresting. Take the papers read before technical institutions, for example. In nine cases out of ten a great portion of the matter which they contain can be deleted without in any way robbing them of useful information. Abstracts of such papers which appear in the technical press are frequently far more valuable than the papers themselves, simply because the superfluous matter has been removed, the sentences reconstructed and the whole put into shape so that it forms more interesting reading.

Conciseness on the part of technical writers is desirable from more than one standpoint. Apart from any other consideration, men engaged in engineering and kindred pursuits probably have less time upon their hands than any other section of the community, and, as a result, the practice of cutting everything down to an absolute minimum number of words becomes extremely important. In addition, conciseness naturally gives rise to more readable productions, and due attention to this point increases the value of technical literature very materially. Strange as it appears, professors accustomed to teaching students are frequently poor technical writers, and the books which they produce are sometimes of little value, notwithstanding that, as teachers, they may possess considerable ability. There are, naturally, exceptions; but, taken as a whole, the textbooks turned out by professors leave much to be desired, and it is doubtful whether students derive much benefit from many of them. In the first place, professors are busy men, and the books which they write are turned out in spare moments. Their manuscript is a kind of repetition of the blackboard work, and it rarely happens that one finds that any attempt has been made to make the subject the least interesting. On the contrary, the most that is usually attempted is to lay down the facts in black and white, and the reading of such works quickly becomes tiring. But apart from the question of cultivating a style and making an endeavour to fix the reader's attention, the field which many such authors attempt to get over between one pair of covers is often absurd in the extreme. Books entitled electrical engineering, for example, are not quite so popular as they were in the past; but, at the same time, one occasionally meets with them. It is a brave man who attempts to write a book covering such a field nowadays, for the advances which the industry has made during the past few years are enormous, and to deal with everything in a manner anything approaching adequate in a single volume is impossible.

Whilst speaking of text-books, attention may be directed to the fact that, although the authors almost invariably set examples to be worked by the students, it frequently happens that no answers are given. Possibly the authors imagine that, if the answers are included, students will not trouble to work the examples; but, speaking generally, the practice of omitting the answers is to be regarded as undesirable. Another reason for the omission of answers may be that the authors do not take the trouble to work out the examples themselves. Take books on the theory of alternating current, for example. These are read not only by students in the ordinary sense of the word, but by engineers and others whose duties have suddenly rendered necessary the acquirement of knowledge of this kind. Nothing is of greater value to such persons than to be able to test their knowledge, and the inclusion of the answers to questions enables them to do so. Students who mean business and take up study with the object of acquiring knowledge which will assist them in their subsequent careers, and not merely to satisfy the requirements of their teachers, will not refer to the answers until they have worked the examples, and, failing to arrive at the correct solution the first time, will strive hard until the correct answer is obtained.

Mathematics treatments frequently play a prominent part in advanced text-books written by professors, often to an extent seldom, if ever, used in practice, and which few practical men can follow. In fact, it appears very difficult for men equipped with a highly mathematical training to go very far without bringing their knowledge in this direction into play, notwithstanding that by so doing they are materially reducing the circulation of their work. At the same time, however, there is abundant evidence that professors and others who set out to write highly technical works are beginning to realize that books which demand only a slight knowledge of this subject are most in demand, and the endeavours of such writers to avoid the employment of the higher mathematics are now well marked. Until a few years ago almost every book on alternating currents demanded considerable mathematical attainments on the parts of its readers, but to-day things are different. Several excellent books are now procurable which will provide the practical electrical engineer with all he will require to know about alternating currents without demanding more than an elementary knowledge of mathematics. The same applies to books on steam, mechanics, hydraulics and other subjects with which the engineer has to associate himself. In writing these highly mathematical books for engineers, professors overlook the fact that unless a man is a natural mathematical genius the attainments which these works demand take years to acquire, and that the ordinary individual, with numerous other things to learn, has insufficient time to develop a high standard in this particular subject.

The inclusion of historical information in up-to-date books on engineering subjects is not generally to be regarded as desirable, for it seldom proves valuable, and in most instances the space which it occupies might be employed for a more useful purpose. Usually such information is given merely for the purpose of padding.

Those who keep an eye on the productions of technical publishers must notice that, immediately some form of machine or appliance springs into prominence, there at once follows a flood of literature pertaining to it. In fact, before anything is really known about a new development experienced writers manage to turn out books upon it; but in most cases they are more or less historical, and the information is not infrequently culled from the patent files. A few years ago there was a tremendous flood of literature on steam turbines, and to-day we are experiencing a similar boom in literature on aeronautics. A good deal of rubbish has been written on both these subjects, and the number of really good books is still small. Seldom does it happen that practical men, in possession of knowledge which would prove of real value to their fellow workers, write books, and there are several reasons for this. In the first place, comparatively few such engineers are capable of setting forth their knowledge in a satisfactory manner; secondly, engineers are frequently shy in giving away valuable information which has cost them much to attain; and, thirdly, the time that an engineer has at his disposal for writing is frequently very small. In addition, a man who is engaged in a works, for example, runs the risk of getting himself into serious trouble if he gives away his firm's secrets. For the same reason as the latter, it seldom happens that any valuable information is brought forward at the discussions which take place at the headquarters of our engineering institutions. Perhaps of all technical literature—if it may be classed as such—none is more important than trade publications, such as pamphlets, trade booklets and catalogues. Engineering firms frequently spend large sums of money on printing, fine art paper and expensive blocks, yet the compilation of those publications is entrusted to people quite incapable of dealing with the job. The result is that the descriptive matters which they contain is often almost unintelligible, and it is difficult to see what useful purpose such productions can serve. Manufacturers frequently overlook the fact that technical writing, like most other things, demands experience, and by practice alone can satisfactory work be secured. It does not follow that because a man is capable of dictating a letter or drawing up a specification he is the best individual to deal with the compilation of pamphlets and similar publications. The work of preparing literature of this kind should only be entrusted to someone who has cultivated a literary style and who is capable of making that which he writes as concise and interesting as possible. Realizing this fact, some firms first allow their new productions to be dealt with by the technical press and afterwards issue the articles so published in the form of reprints.

A few of the large firms employ a special publicity staff, whilst others place the work in the hands of an outside expert. It is a regrettable fact, however, that many manufacturers do not appreciate the necessity of special knowledge for the compilation of trade publications, with the result that very poor work is frequently turned out and much money is so wasted. Technical literature might be improved in many directions, and it is to be hoped that, as time passes, the standard will rise.

# DIAGNOSING AN INDUSTRIAL DISEASE

## IV.—FACTORY FIRE DRILLS

By H. F. J. Porter

SINCE the fire in the Triangle Shirt Waist Company's factory in the Asch loft building, at Washington place and Greene street, in New York, on March 25, in which nearly 150 people lost their lives, there has been a persistent demand on the part of the public for legislation calling for compulsory fire drills. This demand was possibly initiated by my articles on factory fire drills, the first of which appeared in this magazine in August, 1905, which have appeared from time to time since then in other magazines and elsewhere, especially since the holocaust in Newark, and by the publication in the press, the day after the Triangle Waist Company's fire, of a letter which I had written to the proprietors of this factory some time previously calling attention to the dangerous conditions which existed there and offering to install a fire drill for them, which letter was never answered.

### THE TERM A MISNOMER

From what I have read in the press on the subject of fire drills, it seems to me that there is a general misconception in the public mind of what a fire drill actually is; in fact, most people have an idea that it is a sort of game for school children, which they play once a week or so, and I suppose this has come about because the term is a misnomer. That a fire drill is something essentially different, perhaps I can make plain by a simile, as follows:

For instance, in the manufacturing field it is customary, when a man orders a mechanism to be built, to furnish plans and specifications for its construction and to require before final acceptance of and payment for it that an operating test shall be carried out to show that it will work satisfactorily and that the specifications have been complied with. The fire drill is a similar final operating test which should be applied to a building by its architect or designer before its acceptance by the prospective owner in order to demonstrate that it is properly designed to allow of a rapid egress of its occupants in case of fire. Such a requirement has been made for public school buildings, and has resulted in the development of a specific type of architecture for them; but it has not been made for other buildings, and, therefore, as is usual under similar circumstances, the latter have not been developed to meet it. The fire drill, or rapid egress test, must be a requirement in the mind of the designer of the building while he is planning it. It can hardly be presumed that the building should respond satisfactorily to a test for a performance after it is built if such a performance was not considered previously.

### THE FUNCTIONS OF A FIRE DRILL

Now a fire drill as finally developed has several functions. The first, which has just been described, is to so arrange the design of the building that an ample number of passageways and exits of sufficient capacity are supplied to allow the rapid egress test to be carried out. The second is to establish rules for the development and subsequent maintenance of conditions which will tend to prevent the occurrence of a fire. The third is to develop facilities so that in case a fire should occur it will be put out in its incipiency. The fourth is to notify the Fire Department that there is a fire, and to take the occupants out of the building in such an easy, normal way that there will be no panic, and yet so rapidly that they will not be subjected to injury by the fire or the smoke accompanying it. And the fifth and last is, to inspire confidence in the minds of the occupants of the building that there is little likelihood of a fire; that if one should occur it will in all probability be promptly extinguished; that, at all events, they will not be left to haphazard or spontaneous search for safety, but will be taken care of in a prearranged and carefully considered system. All of this relieves anxiety of mind and tends to preclude panic when the emergency arises.

It is probably because it has been known to the public officials and others that I have advocated this fire drill requirement in all kinds of buildings where many people assemble that recently, in anticipation of legislation making fire drills in such buildings mandatory, a large number of manufacturers have asked me to introduce a fire drill in their factories. Some of these factories occupy one or more floors in so-called loft buildings of the standard type, 100 feet square, from ten to twelve stories high, of which there are hundreds in the city.

### THE REQUIREMENTS OF A FIRE DRILL

In order to establish a satisfactory drill in a place of this kind several things are necessary. In the first place, a suitable fire alarm signal system must be installed in the building for the purpose of notifying promptly the occupants of all the floors, not only when there is a fire, but also what floor it is on, so that those who are on floors above it may know their danger and act accordingly, and that the fire fighters who may be scattered through the building may know where to go to put the fire out. Although this requirement is a legal one in accordance with Section 762 of the Greater New York Charter, there are scarcely any buildings in the city in which it has been enforced.

The next thing is to secure the cooperation of all the other tenants of the building in a general fire drill, so that in case a fire should occur on any floor the occupants of that floor, on leaving it, would find their place on the stairway reserved for them in an orderly drill involving the occupants of the other floors of the building. It would be useless to establish a drill on one floor only, leaving the other floors undrilled, for in case of a fire the employees of that floor could be taken only to their door or fire escape, and there they would find further progress blocked by the occupants of the other floors, who would be attempting to effect their escape in an uncontrolled outrush. Such a drill would not accomplish the desired egress from the building.

The first thing that I have found it necessary to do, therefore, after receiving a request for a fire drill has been to send an expert insurance susveyor to look over the whole building in which my client is located, and then to make a study of the complete situation from his report. This study includes the design and construction of the building, the layout of machines, partitions, etc., on each floor, and the number of the occupants of each floor.

### ABNORMAL CONDITIONS

As a result of a great many such studies of late, I have found that in almost all instances these loft buildings of the type above referred to are filled with operatives, more than 100 people to the floor, more than 1,000 to the building. In some cases the number is as high as 300 and over to the floor.

Now these buildings have only two stairways and a rear fire escape, and, as these means of egress have a definite limited capacity, I find that,

STANDARD NEW YORK LOFT BUILDING, 100 FEET SQUARE, ELEVEN STORIES HIGH.

in an orderly drill with a continuous flow of people two abreast down all three of them, it is not possible for them to take down more than 90 people (i. e., 30 people per flight of stairs) from each floor without causing collisions or jamming, and if the stairs are too narrow to permit two people to go down abreast they will accommodate only half that number. But it is not desirable to utilize all of these stairways for egress purposes, for if all are so occupied none of them can be used by the fire department on its arrival at the building to reach the location of the fire. And besides, it is manifestly improper to count upon using all three of these means of egress in case of fire, for undoubtedly one of them would be cut off by the fire and so rendered inaccessible. Therefore, where there has been an occupancy reported in excess of the capacity of two of these stairs, or 60 people per floor, I have been compelled to state to my clients that it would be impossible to establish a fire drill in their premises for which I would be responsible. In other words, these buildings do not meet the rapid egress test.

### LOFT BUILDINGS FAIL TO MEET THE RAPID EGRESS TEST

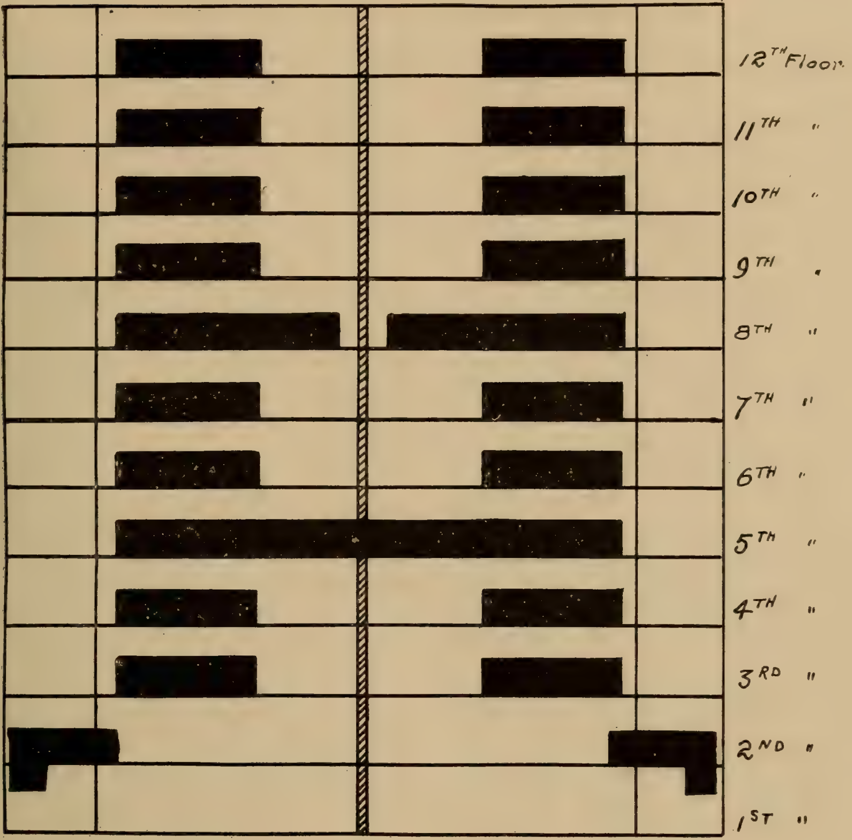
Now in what respect does the test show that these buildings fail? It shows that the loft buildings in the city as constructed were originally intended to be leased to mercantile houses for show-rooms, with very few people on each floor, but have since been converted into factories, and, as so utilized, have too few exit facilities to accommodate the many people that are working in them, so that in case of a fire it would be utterly impossible for these people to make their safe egress from them; or, in other words, they would have to do as they always have done, either jump or burn to death. After a holocaust such as the Asch building fire, people have said with regard to the people who were killed, "If they had only waited awhile before jumping," or "If they had not lost their presence of mind," etc., "they would have been saved"; while, in fact, they had only the two alternatives mentioned. Some selected one, and others the other. On Thursday, May 4, while this was being written, a panic occurred on account of a cry of fire at 548 Broadway, and the staircase, after being filled, was unable to bear the pressure of the congestion and burst, injuring more or less seriously a score or more of girls. This means, therefore, that if we are to have no more recurrences of such calamities either more and better exit facilities must be supplied in all these buildings or the number of occupants per floor must be tremendously restricted. Both of these requirements are practically out of the range of possibility of accomplishment, for there would not be room in the buildings for the extra stairways and the employers could not cut down their working forces to the required number. But even supposing that these requirements could be brought about, it is manifestly unreasonable to suppose that under fire conditions a drill would work with absolute perfection in buildings which were not originally designed with such an egress test in mind, and were simply adapted to it afterwards as best they might be; and, therefore, some further means should be developed for getting the people who are in the danger zone out of it promptly.

### SANE BUILDINGS IN A CIVILIZED COUNTRY

In other words, the state of civilization which we have attained in this twentieth century should demand that in the greatest city on this continent and the second in the world, buildings should be so designed and constructed that the lives of their occupants would never be in jeopardy.

### THE FUNCTIONS OF THE FIRE DRILL SHOULD BE INVOKED

The first function of a fire drill, that factory buildings should be designed for a rapid egress, should be at once applied to bring about safe conditions in these buildings. This I have done in a number of instances, both in old buildings and in new ones, and have brought the results of my experience to the attention of the Committee on City Departments representing jointly the New York Chapter of the American Institute of Architects, the Building Trades Employers' Association and the American Institute of Consulting Engineers, who have invited experts from the Board of Fire Underwriters, the superintendent of the Building Department of the city and others to assist



VERTICAL SECTION OF LOFT BUILDING, SHOWING CONGESTION ON FIFTH AND EIGHTH FLOORS. People on second floor are being dismissed and are part way out, and are going down stairs on each side of the building.

them in a proposed revision of the building code, and I have secured their approval of a measure which I advocate as a safety device and which I claim will meet, in connection with a fire drill, the demands of the situation in making all of these buildings safely tenantable.

This suggestion does not require a radical departure from the old type of architecture; in fact, it merely supplements it by an addition which exists now in isolated instances, the advantages of which have long been recognized. When demanded generally, however, it would bring about practically a new type of building.

### FIRE WALLS A NECESSITY

My suggestion is that a fire wall be built, extending across each building as near its centre line as possible, and extending from cellar to roof unbroken except by doorways, and it should so divide the building as to have a stairway, an elevator and a fire escape on each side of it. This fire wall should have at least two doorways in it on each floor closed by automatic fire doors. No fire could occur on both sides of this wall on any floor at the same time, except under incendiary conditions, and in case of a fire on one side of it the occupants of the building on that side, when advised of danger by the fire alarm, would have only to walk through the doorways to the other side, close the doors, and be as safe as if they had gone into a separate building. A doorway wide enough to pass two people abreast will accommodate 120 people per minute, so that these buildings, no matter how many stories high or how many people there would be on a floor, could thus provide for the safety of their occupants so quickly that no one's life would be endangered by the fire. That section of the building which they had left being emptied, the site of the fire could be easily and promptly reached by the fire fighters, who could go there by the empty stairs. Then if the fire is promptly extinguished the people could go back to work, or if it could not be successfully coped with and should get beyond control, they could go down by the stairs or elevator at their convenience in safety without encountering any smoke. This fire wall arrangement is shown in the accompanying illustrations.

This type of building I have termed "the bisectional" type, as indicating the nature of the construction.

I am now engaged, with others, in drafting a Compulsory Fire Drill bill for the Legislature at Albany, which is based on requiring all factory buildings to be emptyable in six minutes, which is as long as it would be safe to allow people to remain in a burning building. Loft buildings of the type referred to, twenty stories high, can be emptied within that time by the introduction of sufficient stairways to accommodate the number of people now in them or by reducing the number of occupants per floor sufficiently, so that the present stairways can accommodate them, or by erecting the fire wall, as described. Building owners can take their choice, and will find that, generally speaking, the fire wall will be the cheapest measure to adopt. A similar requirement should apply to department stores, hotels, apartment houses, theatres and all public places where large numbers of people congregate, and could easily be arranged in private residences as well.

### MEANWHILE DEFECTS IN OLD BUILDINGS MUST BE REMEDIED

The application of a fire drill test in existing buildings brings to light obstacles and obstructions to the rapid egress of the present occupants if they should attempt to make it. My preliminary survey of many of these loft buildings shows that they have outside fire escapes on their front which lead to a balcony on the first floor, where there is a drop ladder connection to the ground, and that this ladder is almost invariably out of place and in many cases has been removed altogether. Even when the ladder is in place it is so heavy that it requires from two to four strong men to detach it and lower it into position for use. In one case in this city, recently, where a man endeavoured, unaided, to put one in place, and that at a time when there was no fire and he was not hurried, he nevertheless lost his balance and fell with it to the ground and was killed.

In order to make these fire escapes serviceable, this ladder should be put in place in all instances and arranged so that it not only cannot be removed, but can be raised and lowered easily by even a girl, who may be the first person to arrive at the spot and have to use it in case of fire. This arrangement can be accomplished merely by fastening a chain to the top of the ladder and running it over a pulley and fastening a weight on its end to act as a counterbalance.

If the requirement is made that all existing drop ladders should be thus equipped it would be found that many are too short to reach the ground. Some of these may be seen along Fifth avenue, where building fronts have been altered and the lower fire escape balcony removed; but the drop ladder suitable for the lower balcony is retained and hung up on the upper balcony. On many of these buildings a cantilever stairway could be supplied in place of a ladder.

The fire escape on the back of these buildings generally leads down into a closed court, egress from which can be obtained only through the hallway of the main building to the street. In many cases I find that the door leading into this hallway has no knob on the outside, and, as there is a latch on the inside, the people using the fire escape could not open the door and would find themselves trapped in the court. These latches should be removed.

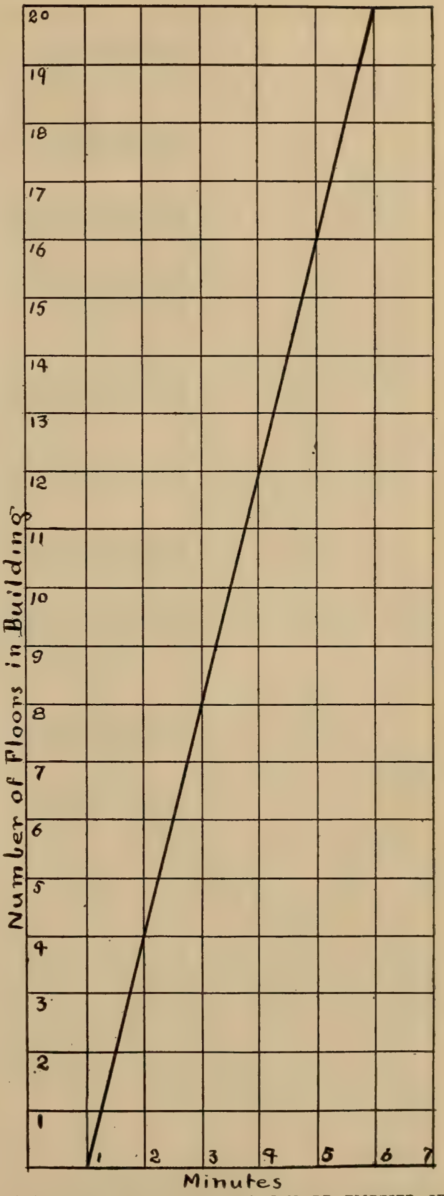
All of these fire escapes should be enclosed in wire glass, so as to prevent smoke and flames getting into them while the people are escaping from the building by them.

I find also that in some of these buildings where a manufacturer uses more than one floor, or possibly two or three upper floors, he has placed a gate in the stairway. This gate is opened from the inside so that people coming down the stairs can get out: but it prevents people going up, as, for instance, employees who are late or other persons wishing to enter the establishment without coming through the front door.

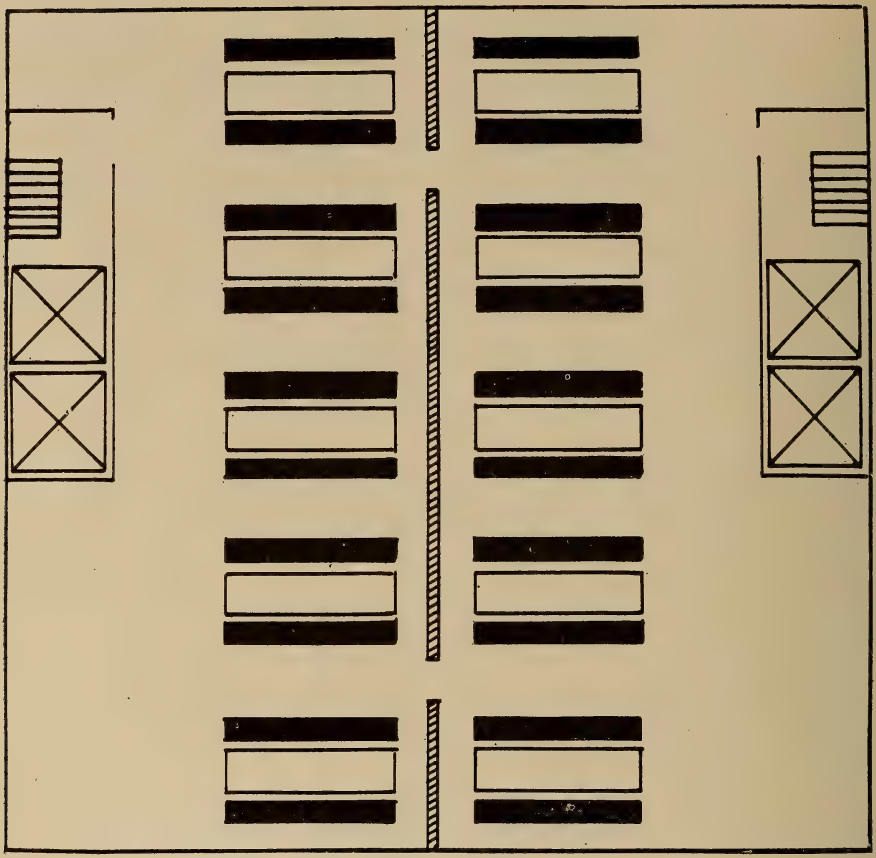
Inasmuch as under emergency conditions the occupants of the upper floors would not be able to get downstairs at all, owing to the large number of people who would be already on the stairs, the only escape for the occupants of some of these floors would be by going upstairs to the roof and thence to adjacent buildings, or, in the absence of the latter, possibly even remaining up there until the fire would be extinguished. Under these circumstances the gate would serve as an obstruction to a possible escape. It should, therefore, be removed in all cases. In almost every factory I have visited I have found benches or machines obstructing access to the fire escapes. The doors to almost all lofts open inward, and the main door to the building does also, if it is not a revolving door, both of which are dangerous.

Irregularities of the kind above mentioned have been reported to the proper city department, but as these departments are all overcrowded now, it is doubtful if action on them all can be taken for many weeks.

It is to be hoped that the demand for automatic sprinklers will be successfully legalized; for, in spite of the statement that there is a trust in this fire-preventive apparatus, I can state positively that this is not a fact, for there is at least one firm which is independent and competes successfully in this field. Sprinklers are intended to put out fires automatically at night



TIME IN WHICH A BUILDING CAN BE EMPTIED IF STAIRS CAN TAKE TWO ABREAST AND 30 PERSONS PER FLOOR.



ARRANGEMENT OF TABLES ACCOMMODATING TEN OPERATIVES AT EACH.

when everything is closed up and there are no drafts. In the day time, when the windows are open, the fire-fighting brigade of the fire drill will have to be relied upon in addition.

Wire glass and metal trim for windows and doors should be required in place of plain glass and wood.

### ESTIMATED DRILLS ARE PIPE DREAMS

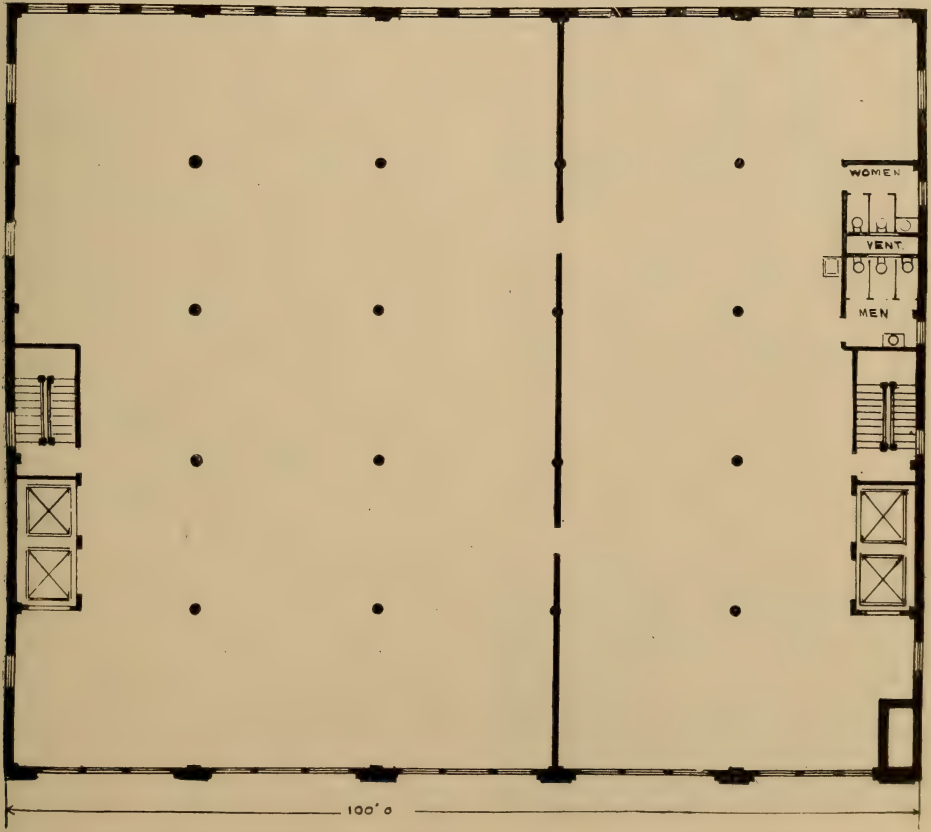
Owing to the demand for compulsory fire drills, above referred to, there has been considerable exploitation in the press of late on the part of certain manufacturers that their factories are safe on account of their having established in them a fire drill. Whether these drills have been installed in accordance with the suggestion by the Superintendent of the Public Schools that manufacturers employ the minor principals of the schools or not or by retired firemen, I do not know, but most certainly the drills referred to are of the only type that these school teachers or firemen have had any experience in installing.

These manufacturers state that the drill would operate as soon as they would be advised of a fire, but how they would be so advised in the absence of a fire alarm system, which absence I have stated is general throughout the city, if the fire should be elsewhere in the building than in their own loft, is not referred to. They then say that their employees are drilled to rise in their places, form in fire drill order and walk to the doors, which are held open by guards who are assigned to that duty, while the fire-fighting corps of employees seizes the fire extinguishing apparatus and attempts to put out the imaginary fire. Then they *estimate* that they could get their employees downstairs and out of the building in so many minutes. In the lofts of the building at 548 Broadway when the panic above referred to occurred fire drills of this kind were installed, and, of course, failed when put to actual test.

A new theatre recently carried out such a fire drill as a demonstration to the press. This drill was carried out in an empty theatre by a few employees, one of whom sent in the alarm, another lowered the asbestos curtain, another raised the skylight over the stage, others opened the exit doors and held them open. Then the proprietor *estimated* that *if* there had been an audience present it would have gotten out in 3 minutes.

Another demonstration of a similar nature was carried out a few days ago at the Appraiser's Stores, on the West Side of this city, in which the effectiveness of a "down and out" chute as a fire escape was shown. Ten men came down by it from the roof of the ten-story building in a few seconds. How it would have handled 1,000 people, 100 people entering the openings on the side at each of the ten floors, was not demonstrated or even estimated, and it goes without saying that it would have been entirely inoperative.

All of this sort of thing is misleading, tending to convey to employees present and prospective and the public generally that the premises are safe. It means absolutely nothing to anybody about the handling of a crowd. A crowd cannot be han-



FLOOR PLAN, SHOWING FIRE WALL WITH TWO DOORWAYS IN IT AND A STAIRWAY ON EACH SIDE OF IT.

This building has from 50 to 60 people on each floor, except the sixth, which has over 150, and the eighth, which has about 100.

dled in a man's mind, as these people try to make others think it can.

### PRESENT TYPE OF FACTORY ARCHITECTURE A FAILURE

It has been frequently stated to me when I have advocated fire drills in factory buildings that drills work all right in the public schools where there are plenty of wide stairs and the type of occupants to be drilled are amenable to orders, and that they may work all right in factory buildings till the actual emergency would arise, and then there would be a panic and they would fail. It would seem as if it had been instinctively felt that our factory architecture of the modern type is defective, and people have been willing to accept as a fact that architects can build only fire-traps for factories. Fire drills of the type just referred to would not work in case of a fire, it is true; but they are not fire drills of the type which would serve as rapid-egress tests, for the latter cannot be installed where conditions would prevent their practical operation. Changes in conditions would have to be made to meet the requirements of the test; then they could be installed and would work when the emergency would demand it of them. Architects can build any kind of a building that may be called for, but if a building is wanted from which a rapid egress is expected it must be so ordered in advance.

### COMPULSORY TESTS NECESSARY TO DEVELOP SATISFACTORY BUILDINGS

The compulsory fire drill test is necessary, not only to bring about a type of building which will meet the requirements of the service to which it will be put, but to keep conditions in them such that fires cannot occur.

### EDUCATION NECESSARY TO ESTABLISH PUBLIC SENTIMENT

The public must be made acquainted with the fact that the people working in the loft buildings in the city cannot escape from them in case of fire as they now stand. I feel that if the public once gets this idea well in mind it will insist upon the necessary changes being made or else closing the building.

It is evident, also, that considerable work will have to be performed upon our loft factory buildings before they can be put into a condition where a fire will be extinguished in its incipiency and before the working people in the danger zone of that fire can be removed to a place of safety without entailing an injury from crowding or rushing them down dangerous stairs or fire escapes in smoke or flames in panic conditions.

### A LOFT BUILDING COMMISSION LIKE THE TENEMENT HOUSE COMMISSION

Having brought the seriousness of this situation to the attention of the Fifth Avenue Association at a meeting called for the purpose, it was decided to seek the co-operation of other bodies which were taking an active part in studying the situation in applying to the Legislature for the appointment of a commission, consisting of nine men, two from the Senate, three from the Assembly and four experts, architects and engineers, to study the laws of this country and Europe and devise the best means of developing safe and sanitary buildings for the housing of industrial establishments where many people are employed.

In pursuance of this decision, a delegation of the association, with representatives from the Safety Committee established since the Asch building fire, visited Albany on Monday, May 8, and presented the matter to the Governor and the majority leaders of both Houses.

The expense attendant upon the necessary developments may make the subsequent rentals too high for manufacturers to pay, and thus manufacturing may be driven from the city. This, after all, would be the best thing that could happen, for it would cause a cessation of the congestion in certain sections which has, so far, seemed to be impossible of amelioration, and thus help to cure the city industrial disease.

# A NEW STABILIZING DEVICE

## THE SHIP WHICH CARRIES HER OWN WAVES

**By Alwin Waters**

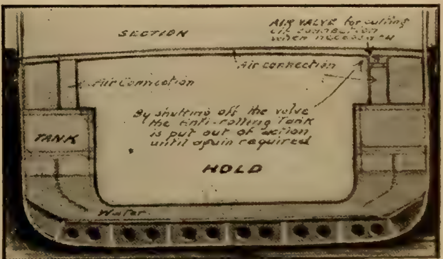
THE dream of inventors who have been working for years to discover some device to stabilize a ship at sea under all conditions has at last been realized. After fruitless experiments with gyroscopes and keels of ingenious construction, the ancient problem has at last been solved, at once simply and effectively. In a series of exhaustive tests recently made on a large ocean-going steamer the motion of the ship was brought absolutely under control.

The new stabilizing device has been described as "a ship carrying her own waves." It is the invention of Herr H. Frahm, a Hamburg engineer. Briefly, the new device consists of tanks partly filled with water so contrived that the action of the waves upon the ship is counteracted. The actual tests of the new device were made upon the S.S. *Ypiranga* and *Corcovada,* of the Hamburg-American Line, during several trips between Europe and American ports. The *Ypiranga* is an 8,000-ton boat, and is, therefore, more subject to rolling than bigger ships.

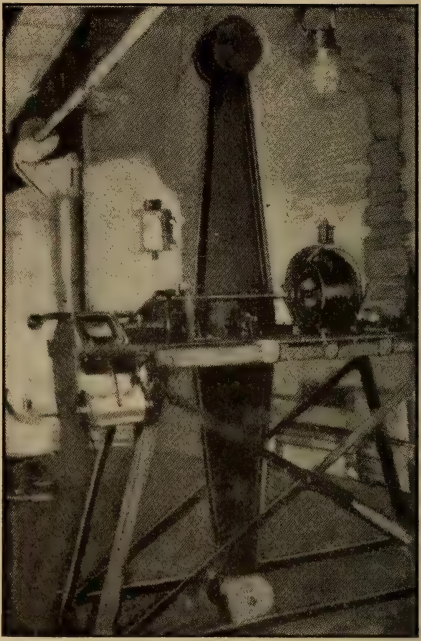
The tanks are in the form of a very broad "U," running the full length of the ship. One of these tanks is placed forward and the other in the stern. In the actual tests the *Ypiranga* was labouring in a high sea when the rolling exceeded 13 degrees each side from the vertical. It will be seen that this is a very lively ship, and one which would test the health and happiness of all but experienced sailors. With one tank in operation, this rolling was reduced to between 5 and 6 degrees. When both tanks were in use the lateral motion of the steamer was between 2 and 3 degrees. The great steamer ploughed along through heavy seas with a scarcely perceptible tremor.

The operation of the Frahm tanks is extremely simple. About 195 tons of water are distributed into two tanks. To picture the action of the water, take a glass half filled with water and strike your finger against the side of it, giving it a sharp, quick rap. The water in the glass, it will be noticed, tends to rise on the side on which the blow is struck, and not on the opposite side, as might be imagined. The great Frahm tanks operate in exactly the same manner. The impact of the waves against the side of the ship stirs up a wave in the tanks just as the tap of your finger causes the water to rise in the glass.

In the case of the "U"-shaped tubes the water which rises against the side that is struck is backed by the whole pressure from the connected tank, the other side of the "U," which immediately fills the vacuum created and provides powerful counter force to the ocean's waves. The new invention will work with even more surprising effect on


SECTION
AIR VALVE for cutting
when necessary
Air connection
Air Connection
By shutting off the valve the anti-rolling Tank is put out of action until again required
TANK
HOLD
Water

ARRANGEMENT OF THE ANTI-ROLLING TANK ON BOARD THE GERMAN EAST AFRICAN LINER GENERAL larger steamers. The experiments of the *Ypiranga* have determined the Hamburg-American Line to equip their new steamer, the *Imperator*—the largest ship in the world—with such tanks. The S. S. *Victoria Luise,* formerly the crack *Deutschland,* which is to be used exclusively for cruising purposes, will also be equipped with non-rolling tanks, as will the great *Kaiserin Auguste Victoria,* of the same line. Since the rolling of these monster liners is comparatively slight, even in heavy seas, they may be made almost immovable by the new device in the roughest seas the Atlantic can offer.

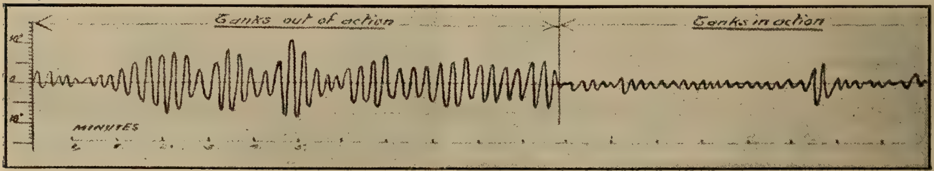


THE ROLL PENDULUM FOR RECORDING THE ROLLING MOTIONS OF THE SHIP

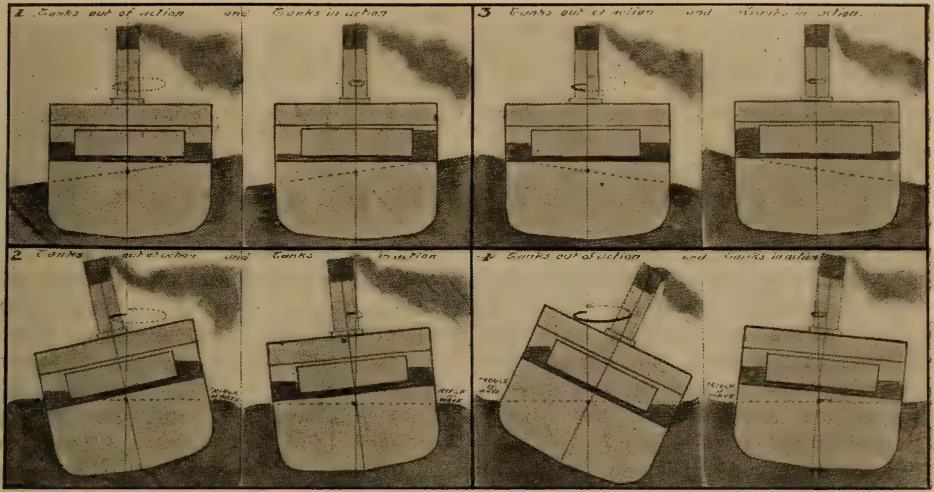
Fighting fire with fire is an old method of checking the prairie conflagration. Fighting water with water is the new plan for meeting the rolling action of the waves, and there is every reason to believe that with the Frahm stabilizing tanks the vessels of the Hamburg-American Line will conquer the oscillations of steamships to such a degree as will remove, to a great extent, the motion to which so much of the discomfort of seasickness is due. When the wave which would ordinarily cause rolling strikes against the side of the ship it is met by one of equal power acting in the opposite direction, and the vessel itself remains practically uninfluenced. The sweep of the wave outside passes through the sweep of the wave in the tank inside of the vessel, and the ship remains quiet, much in the same manner as an ivory billiard ball will pass the blow which strikes it on one side to the ball which is touching it on the other and lie stationary itself.

In explaining the action of the tanks Herr Frahm says: "This result has been obtained by the most careful application of the laws of resonance. Under the effects of resonance, bodies that can oscillate about a condition of equilibrium are made to swing severely under comparatively small impulses as soon as the period of oscillation of the impulse is synchronous with the individual periods of the respective bodies. A ship constitutes a body of this kind, as she will oscillate under the impulse of the waves.

"As is well known, a ship will roll almost exactly in the periods of her individual oscillations. Large heeling amplitudes can only be produced



ROLLING DIAGRAMS RECORDED BY THE PENDULUM OF THE S. S. GENERAL IN THE BAY OF BISCAY, ON MARCH 10, 1911


1 Tanks out of action and Tanks in action
3 Tanks out of action and Tanks in action.
2 Tanks out of action and Tanks in action
4 Tanks out of action and Tanks in action

FOUR CHARACTERISTIC PHASES OF SHIP'S ROLLING WITH THE ANTI-ROLLING RANKS IN AND OUT OF ACTION

on a ship when she is struck by a series of comparatively regular waves and struck in the measure of her individual number of oscillations. Under such circumstances the influence of resonance will be promptly felt, and there will be an increase of the angle of heeling from wave to wave. All large rolling amplitudes observed in practical seafaring are due merely to the influence of resonance between wave and vessel.

"On this fact the present device has been based. It utilizes a secondary and artificial resonance in order to annihilate the influence of the primary resonance between waves and ship. This secondary resonance is introduced by means of a U-shaped tank, located athwartship and extending from side to side, in which a water column can oscillate with the same number of swings per minute that are peculiar to the particular ship under consideration.

The ship will heel only as far as the water under the action of secondary resonance, rises or falls in the vertical tanks to such an extent that the heeling moment imparted to the ship by the waves is balanced by the opposite turning moment, produced by the oscillations of the water.

"The increment of heeling, from impulse to impulse, in a free ship cannot take place now, and the rolling motions will be limited to such as will be sufficient to produce the necessary oscillations of the tank water."

# THE DIESEL MOTOR IN AMERICA

THE remarkable efficiency and general high character of the Diesel oil engine are well known to engineers in Europe and America, but its use has not become so widely extended in the United States hitherto as it has in the various countries of Europe. It is interesting, therefore, to note that Mr. Adolphus Busch, of St. Louis, has arranged for the active development of the business in America, and that a company has been formed to advance the use of this remarkable prime mover in the many lines of industry to which it is so well adapted.

In this new company Mr. Adolphus Busch is president; Mr. August A. Busch, vice-president, and Mr. James R. Harris, second vice-president and general manager, and a new plant is under way for the manufacture of the engines by the Busch-Sulzer Bros.-Diesel Engine Company.

The Diesel engine is an internal oil combustion engine, and is built both as a two-cycle and as a four-cycle engine. Ordinary crude oil is used for fuel, and the method by which this fuel is used in connection with the engine is both simple and radically different from that of other types of power. There are no boilers, neither is the fuel used as is gasoline in the automobile engine, although the operation in the latter case is somewhat similar. In the Diesel method of combustion, however, there is no annoying "mixture," neither is there any "spark" or other mechanical or electrical device to cause trouble. The cylinders of the engine (in which the power is developed and applied through the pistons and rods to the driving shaft) contain nothing but air until the "compression" stroke has been completed and until the temperature which results from this compression is more than sufficient to ignite the fuel. The fuel is atomized by air into an extremely fine spray, and is introduced into the cylinder at a rate which does not permit of an explosion, but generates a steady pressure on the piston, as does the steam in a steam engine, the quantity being regulated directly by the governor in proportion to the load on the engine.

The splendid economy of the Diesel engine is due to its ability to operate with entire reliability and with the highest efficiency known in the engineering world to-day on the cheap, safe and increasingly abundant crude and low-grade fuel oils, the production of which is stimulated by the enormous demands for gasoline. After the refining process the bulk of the crude oils produced is left available as a rival fuel of coal in the market, and any upward fluctuations in price would mean a discontinuance of oil fuel in an overwhelming majority of other cases long before there would be any appreciable increase in the cost of fuel for the small quantity of oil required by Diesel engine plants.

The average experience of users of Diesel engines in America shows that the fuel cost of operating an ordinary steam plant is cut down fully two-thirds where Diesel engines are used. Records kept by users of Diesel engines show that the average Diesel engine in service develops 100 horse-power for an hour's time on 6½ gallons of oil.

A further saving of great importance is the elimination of labour necessary in a steam plant for firing, cleaning and repairing boilers and handling coal and ashes. It is to be noted, then, that the cost of this extra labour in the steam plant has been shown in several cases to be actually sufficient to pay for all the fuel consumed by an equivalent Diesel installation.

About fifteen years ago, when the little gasoline engine had first been successfully applied to the propulsion of small boats, the naval engineers of the world recognized the fact that it would be only a matter of time when the internal-combustion engine would be so perfected that it would replace marine steam movers of larger units.

As everyone knows, very marked progress has been made in that direction in every country in the world, and the development of the light oil (gasoline and kerosene) engine has been most rapid up to a very few years ago, when it seemed to have reached the limit of its applicability. In small and medium-sized boats or launches the comparatively high cost of operation with gasoline or kerosene could very well be ignored in face of the wonderful advantage which the system had over the cumbersome steam plant, with its boilers, coal bunkers, etc.; but for the propulsion of larger vessels considerations of commercial economy, as well as fundamental technical difficulties, the gasoline engines seemed to be barred. The conclusion was forced upon the mind of the most enthusiastic supporters of the internal-combustion marine engine that only a cheaper fuel engine could and would continue the march of progress which the little two and three horse-power launch engine had begun a decade or so ago.

The Diesel heavy-oil engine, with its wonderful fuel economy, has been looked upon, since the day of its inception, as the coming conqueror of the 1,000 horse-power or larger steam engine now turning the propellers of the vessels carrying the traffic of the seas; but it has taken years to overcome the engineering difficulties which even this advanced type of engine presented at the start in its application in large units for the propulsion of vessels. The Diesel stationary engine, which is in extensive and highly successful use in all the industrial countries of the world, is working generally on the four-stroke cycle principle and is single-acting, so that with each cylinder there is only one impulse for two revolutions of the shaft. With this type of engine there is considerable difficulty in effecting the reversal of the direction of rotation of the engine, and when these engines were used for marine purposes the astern motion of the screw had usually been obtained by the use of tooth-wheel gearing.

It is chiefly due to years of scientific research and painstaking engineering experiments of Dr. Diesel and the firm of Sulzer Bros., Winterthur, Switzerland, who have been one of the largest manufacturers of Diesel engines in Europe for many years, that finally a marine type was developed which overcame the difficulties and produced an engine which is under perfect control for reversing motion. During the last few years most successful installations have been made in Europe of large Diesel marine engines, the first one of which was the conversion of a passenger steamer on Lake Zürich, Switzerland, into a Diesel-engine driven boat about two years ago. The speed of the vessel was increased by this change of motive power from 8¾ to 12½ miles per hour, a saving of 33 per cent. in weight was effected by it, the cost of fuel was reduced by one-quarter of that of the steamboat, and the fuel-carrying capacity was increased ten-fold.

The examples set by the French Navy in equipping all its submarine fleet with Diesel engines, varying in power from 400 to 900 horse-power, was followed by the Italian Government, whose submarine boats are being equipped with Diesel engines, designed and built in the Sulzer Bros.' shop.

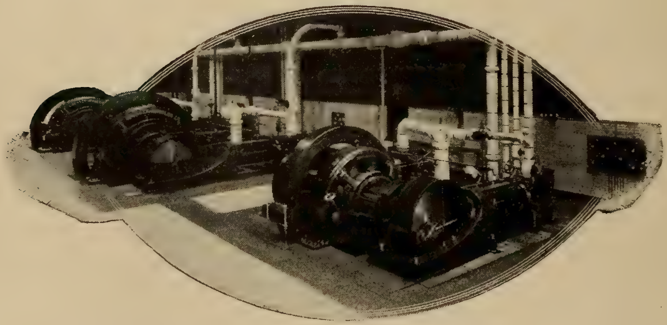
Not only have the naval authorities of the different European countries been awakened to the wonderful advantages of the Diesel engine for marine purposes, but also the large commercial marine companies have recognized that this type of engine will revolutionize the ocean traffic of the world. Official announcement was made by the Hamburg-American Company a short time ago that they will build a large cargo liner whose twin propellers will be driven by Diesel oil engines. The new vessel, which is to be 400 feet long, 52 feet 6 inches wide, 23 feet 6 inches deep, with a tonnage of 8,000 tons, will be fitted with two Diesel engines, each of 1,500 horse-power. The Hamburg-American Company, noted for its highly conservative business methods, can have come to this radical and new departure in the building of large ocean vessels only after the most convincing investigations as to the possibilities of the Diesel motor engine and its commercial economy.

There will be a great saving of space, as a large proportion of the coal-bunker space will be available for cargo carrying or other purposes.

The absence of smoke stacks and the omission of smoke will be one of the most notable features of the new ship. Without visible means of propulsion, the vessel will speed swiftly and silently over the seas, and it probably will seem uncanny to the onlooker; for however accustomed we have grown to the small motor boats proceeding from invisible power, a large ship seems necessarily a creature of smokestacks or sails.

Not the least of the advantages of the new mode of propulsion will be the absence of the stoke hole, that fiery pit in which the strongest men succumb if worked more than a few hours, and whose sufferings are known to few passengers. It is becoming almost impossible to hire men to work in these places, and those who undertake the task are often an unruly element. With the oil engine there will be no great heat and no laborious shoveling of coal, and only a few men will be required to attend the machinery.

A full account of this very important installation of internal-combustion engines on a Hamburg-American liner will be given in a special article in an early number of this magazine.



Mr. George Ward Fuller, whose portrait we publish this month, has been identified for a number of years with an important engineering industry in the United States, being especially known in connection with the A. S. Cameron Steam Pump Works, of New York.

Mr. Fuller is of Scotch-Irish parentage, and was born in New York. His training has been mainly practical, as he left school when quite young, and entered the employ of the Tapscott Packet Line of sailing vessels, after which he became connected with the Westcott Express Company, and subsequently with the firm of Messrs. B. Altman & Co. The A. S. Cameron Company was developed and conducted by its founder, the late Adam Scott Cameron, and upon his death the business was carried on until a recent date by his widow, the management for the past eleven years having been in charge of Mr. Fuller. The success of the Cameron pump has been doubtless due both to its mechanical effectiveness and also to the excellent business management which has been given to its development. Very recently the control of the Cameron Works has passed into the hands of the Ingersoll-Rand Company, this being a natural sequence of the long community of interests existing between the two concerns. Mr. Fuller continues as vice-president and general manager, while Mr. George Doubleday, who is first vice-president of the Ingersoll-Rand Company, becomes president, the directorate being composed of Mr. Fuller and the directors of the Ingersoll-Rand Company.

Photograph by Pirie Macdonald, New York.

GEORGE WARD FULLER.

See Reverse Side.

INDEXED.

CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XL JULY, 1911 No. 3

# THE RAILWAY SITUATION IN TURKEY

JUL 6 1911

## INCREASING REVENUE OF THE VARIOUS LINES

**By Leon Dominian**

The subject of railway transport in Turkey is a matter of increasing importance, not only because of its influence upon the development of the Empire, but also because of its influence upon external relations, both commercial and financial. The extent to which governmental changes have affected railway progress is a very interesting question, while the relation to foreign capital will be found instructive both in Europe and in America.—THE EDITOR.

THE rapidly increasing traffic on Turkish railroads since the establishment of a constitutional form of government in that country is indicative of the importance about to be assumed by that industry. The following statistical figures, compiled from official documents, best indicate a part of the progress attained so far. They show the receipts of the various railway companies from January 1, 1910, to April 10 of the same year, and the increase thereof as compared with the same period in 1909:

| LINES. | Receipts. | Actual Increase. | Per Ct. Increase. |
|---|---|---|---|
| European Turkey: | | | |
| Oriental Railroad | $816,398 | $92,331 | 11.2 |
| Salonica-Dedeagatch | 268,425 | 109,589 | 40.8 |
| Salonica-Monastir | 185,052 | 31,218 | 16.9 |
| Asiatic Turkey: | | | |
| Anatolian Railroad— | | | |
| Haidarpacha-Angora | 334,276 | 88,177 | 26.4 |
| Eskishehir-Konia | 114,458 | 20,493 | 18.0 |
| Bagdad Railroad | 24,132 | 5,264 | 21.8 |
| Smyrna-Cassaba | 265,461 | 21,252 | 8.0 |
| Syrian Railroad | 401,424 | 12,085 | 3.0 |
| Aidin Railroad | 364,809 | 2,036 | —— |
| Mersina-Adana Railroad | 69,806 | 13,288 | 19.0 |

The extraordinary increase in the receipts of the Salonica-Dedeagatch lines was due, to a large extent, to a movement of troops, and cannot be taken in its entirety as representative of an actual augmentation in the volume of freight handled.

Such is not the case with the other lines, however, and the remarkable development of their receipts has been due solely to more prosperous conditions, brought about through commercial activity that has prevailed unhampered by the erstwhile keenly-felt governmental chicanery. All told, a glance at the percentage tabulated here will suffice to adequately convey an idea of the highly satisfactory progress incidental to the inauguration of a liberal government in the country. Furthermore, this fortuitous state of affairs was also reflected in the equally substantial increase of government revenues.

### GOVERNMENT SUBSIDIES

The annual disbursements of the Turkish treasury, covering payments of kilometric guarantees to the various companies operating railroads, have lately amounted to about $3,500,-

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000—a really insignificant total when compared with the natural resources known to be extant in the dominions of the Sultan. This sum will decrease proportionally to the increase of the railroad revenues until a point is reached where railroad receipts will allow a direct participation of the Treasury in the earnings accruing through operations, in accordance with the terms of the various conventions in vogue between the government and the different companies. Incidentally, it may be noted here that the finances of the Turkish Government will be favourably affected in 1910 by this sudden growth of the volume of railroad business to the extent of about $1,000,000. In other words, it is expected that on the basis of the figures here tabulated for the year's first quadrimester[*] there will occur a saving equal to this amount in the subsidies paid out by the Department of Finances at the end of the year.

### THE VARIOUS OPERATING COMPANIES

Limitations of time and space which fell to the writer's lot in the compilation of the following paragraphs will, unfortunately, result in their apparently disconnected appearance. Nevertheless, it is in the hope that the timeliness of the subject may compensate, to a certain extent, for other deficiencies that an attempt is here made to briefly review a few facts concerning the more important Turkish railroads.

Almost everything in Turkey is, naturally, subject to the physiographic differentiations imposed by the extension of the Empire upon two continents. Hence railroads also fall under the two heads of European and Asiatic Turkey.

The following statement is here reproduced from the 1909 report of the Ottoman Ministry of Public Works, and contains a list of the total mileage in operation on November 1, 1908:

| Lines. | Length, Kms. | Kilometric Guarantee Based on Gross Receipts. |
|---|---|---|
| I.—European Turkey: | | |
| Oriental Railroads Co. | | |
| Constantinople— | | |
| Mustafa Pacha[†] | 355.025 | |
| Adrianople— | | |
| Dedeagatch[†] | 148.998 | |
| Salonica— | | |
| Mitrovitza[†] | 362.890 | |
| Uskub-Servian frontier[†] | 84,601 | |
| Salonica-Monastir Ry. Co. | | |
| Salonica-Monastir | 218.566 | $2,860 |
| Salonica Junction Ry. Co. | | |
| Dedeagatch— | | |
| Salonica | 444.938 | 3,100 |
| Bodoma-Ferejik | 38.860 | 3,100 |
| Kilindir-Karasouli | 26.793 | 3,100 |
| Military branch | 1.597 | 3,100 |
| II.—Asiatic Turkey: | | |
| Anatolian Railroads Co. | | |
| Haidarpacha-Ismid | 91.271 | 2,060 |
| Ismid-Angora | 485.565 | 3,000 |
| Hamidie-Adabazar | 8.730 | |
| Eskishehir-Konia | 433.685 | 2,772 |
| Alayund-Kutahia | 10.106 | 2,772 |
| Bagdad Railway Co. | | |
| Konia-Bulgurlu[*] | 200.000 | |
| Smyrna-Cassaba Ry. Co. | | |
| Smyrna-Alachehir[†] | 168.970 | |
| Magnesia-Soma[†] | 92.000 | |
| Bournabat branch | 5.087 | |
| Alachehir-Afionkarahissar | 251.336 | 165.25 |
| Aidin Railway Co. | | |
| Smyrna-Aidin | 129.926 | |
| Aidin-Diner | 247.279 | |
| Paradiso-Bouja | 2.318 | |
| Gazi-Eumerseydikeuy | 1.449 | |
| Tireh branch | 47.868 | |
| Eudemish branch | 25.395 | |
| Seuke branch | 22.130 | |
| Denizli branch | 9.460 | |
| Tchivril branch | 30.571 | |
| Adana Railway Co. | | |
| Mersina-Adana | 67.000 | |
| Damascus-Hama & Extension Co. | | |
| Beyrut-Mexirib | 249.147 | |
| Rayak-Aleppo | 331.912 | 2,720 |
| Jafa-Jerusalem Railways. | | |
| Jafa-Jerusalem | 86.630 | |
| Hedjaz Railroad. | | |
| Damascus-Medina | 1,320.000 | |
| Kaiffa-Deraa[‡] | 161.000 | |
| Moudania-Brussa Ry. Co. | | |
| Moudania-Brussa[‡] | 41.702 | |
| Grand total, kms | 6,192.805 | |

In the preceding table the figures given under the heading of "Kilometric guarantee based on gross receipts" are the ones actually paid out by the government and have been calculated on the basis of 5 francs equaling $1.

### FOREIGN INVESTMENTS

Barring the Hedjaz Railway, all of these lines have been built with Euro-

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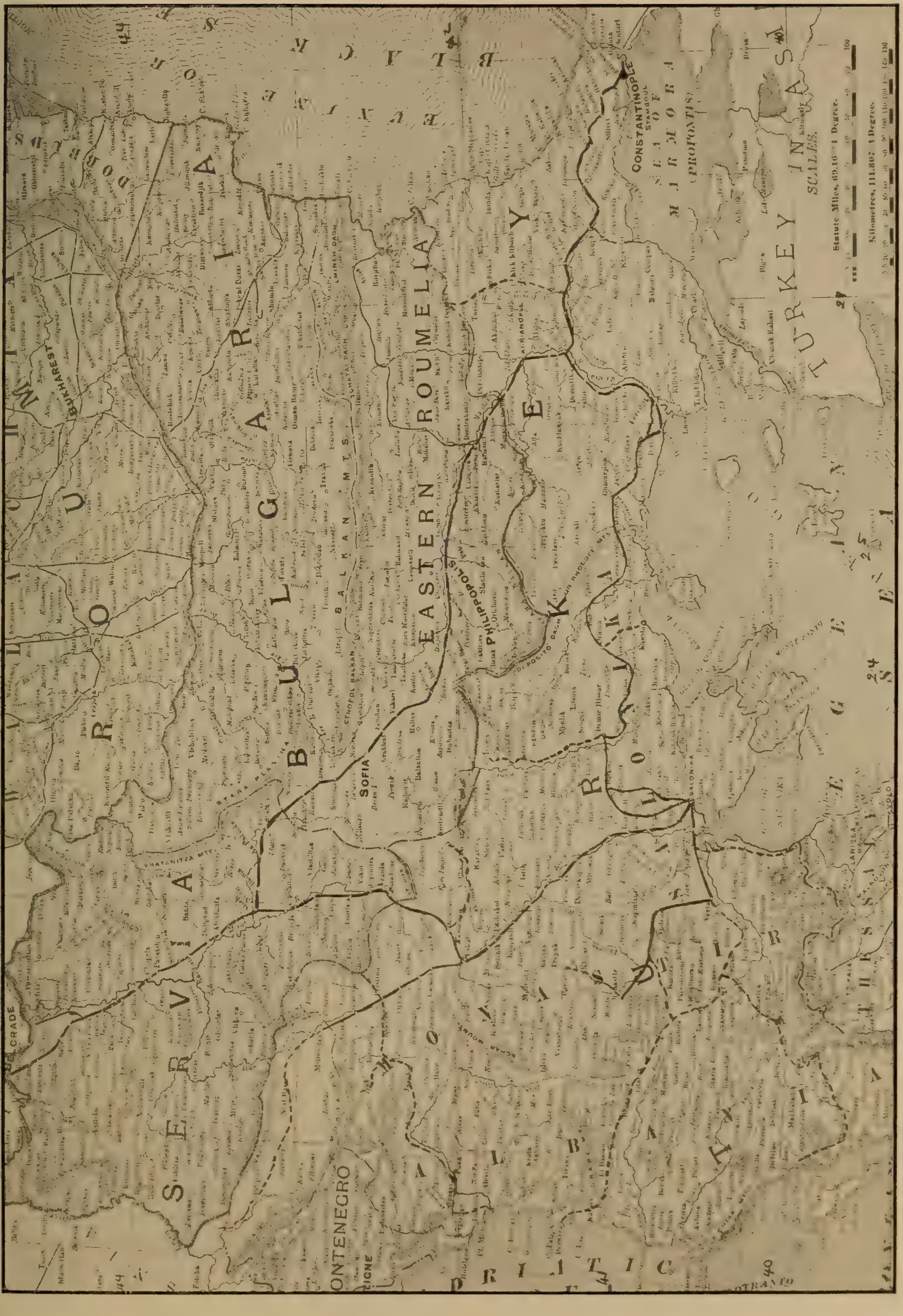
[*] The word is used here advisedly, although the writer is aware of the impossibility of its being found in the dictionary. Its meaning is obvious, and it should have the same right to existence as semester or trimester. See in this connection Barker & Reyes' "The Mining Laws of Mexico." Mexico City, 1910.

[*] Government subsidy on this line as follows: $2,000 net kilometric guarantee, plus $900 per km. for operating expense, plus 40 per cent. of the excess of the gross kilometric receipts beyond $2,000.

[†] State ownership.

[‡] 1 m. gauge track.



MAP OF TURKEY IN EUROPE, SHOWING RAILWAY DEVELOPMENTS. EXISTING RAILWAYS IN SOLID LINES. PROPOSED ROUTES IN DOTTED LINES pean capital, which has found a remunerative field of expansion in Turkey since the latter half of the nineteenth century.

Of the $500,000,000 invested by the thrifty French in various Turkish enterprises, $90,000,000 have been spent in railroads owned directly and managed by Frenchmen. These are the Syrian Railroads, representing a capital of $23,500,000; the Salonica-Constantinople Railway, of $30,000,000; the Smyrna-Cassaba road, of $24,500,000, and the Salonica-Monastir, of $12,000,000.

It should not be overlooked here that the actual amount of French capital invested in Turkey, whether it be in railroads or otherwise, exceeds, in reality, the figures just given. This fact is revealed by a close investigation of the various and devious sources from which German capitalists are wont to obtain the funds required by their multiple undertakings in Turkish territory. A large part of it undoubtedly comes from France, and, while nominally falling under the head of French loans to Germany, is really affected to the furtherance of commercial schemes destined to compete very successfully, as experience is constantly showing, with the former's attempts to hold the trade previously acquired in the Near East.

This concertive action of French capitalists and German statesmen has conspicuously prevailed for a number of years, despite the fact that it has not been countenanced by the general foreign policy of the French Government. But capital is usually selfish and rarely patriotic, and, above all, German statesmen are exceedingly able and possessed, as they have shown to be in the past few decades, of a vast store of resourcefulness, which they have very shrewdly made subservient to the attainment of the world-wide commercial and industrial supremacy, around which their whole political struggles are pivoting.

Over a third of the $150,000,000 invested by the British public in Turkey has been devoted to railway enterprises. Most important of all the British-owned roads is the Aidin Railway, representing an investment of $30,000,000. Although devoid of any subsidy whatever from the government, the road has been a success. It taps the Meander valley, a region richly endowed by Nature and constituting a very fertile and promising district. This line has the reputation of being the best managed in the country, a reputation which English railroad companies usually acquire throughout the world. Every effort is made to maintain its equipment in the best of condition, and in 1905 the track was changed from 70-pound to 90-pound rails, laid exclusively on creosoted fir ties.

Of the German railroad interests in Turkey it may be said that they have been very successful in the acquisition of complete control of the more important routes traversing Asia Minor. With characteristic far-sightedness, it has been understood in German financial and diplomatic circles that the relation of this westernmost Asiatic peninsula to twentieth century Eastern commerce was about to become exactly similar to that existing between the Mediterranean and trade activity aiming at preponderance in Oriental markets throughout the nineteenth century. British ascendancy over points of vantage distributed along the Mediterranean and the Red sea has undoubtedly exerted a paramount influence on the prodigious development of her Eastern trade, a development which ultimately culminated in commercial supremacy previous to the dawn of Teutonic hustling. With the onward march of events, however, the main thoroughfare between the East and the West has been shifted from the watery expanse intervening between the Eurasian and African continents to a more easterly and, at the same time, far speedier overland route, which, piercing the mountainous barriers that fringe the coast of Asia Minor and stretching across the desert plateaus of its interior, wends its way, now across fertile plains, again through heavily mineralized regions, until it reaches the valley of the Euphrates and the Tigris, once reputed to be the granary of the world. These steel-clad tracks, the laying of which has already begun in Asia Minor, are destined to form the connecting links that will bring together products of Western ingenuity and science and the thickly populated regions of consumption in Asia.

### THE BAGDAD RAILWAY

The much-discussed Bagdad Railway will become, upon its completion, one of the main factors in the trade relations of the East and the West. This is hardly the place to dwell upon the intricate maze of political wrangling that preceded the final award of the concession of this line to German interests, in spite of a knowledge of their utter inability to bear, unaided, the financial burden of the enterprise, estimated, as it was, at no less than $180,000,000. Suffice it to say that after a most bitter political campaign, lasting three years and fought between England and Germany on that battlefield of European diplomacy that Constantinople has always been in modern times, and in which the British soliciting syndicate was reported as having offered far more advantageous terms to the Turkish treasury than its competitors, the line was, nevertheless, granted to the Germans on January 21, 1902.

Its starting point was to be Konia, the southeastern terminal of the Anatolian Railroad Company, whence it was to be prolonged in a southeasterly direction to penetrate the lofty Tauric range and connect with the Mersina-Adana Railway. From the Cilician plains the track was intended to cross the northern portion of the Syrian desert, and, striking east, invade the fertile lowlands of Mesopotamia, after which its southern extension via Mossul and Bagdad to Bassora, on the Persian Gulf, was contemplated.

The line was divided into sections of 200 kilometres each, and construction on the first section, extending to Bulgurlu, was begun without delay. This portion of the road was opened to traffic in 1904. Since that time, however, work was abandoned, and, with the exception of a number of surveying parties detailed to report on the succeeding sections, every form of activity was suspended until 1910, when the extension of the grading towards the Taurus range was once more resumed. Certain changes from the original route have also been subsequently decided upon, most important among which is the very recent decision of the management to attain the town of Aleppo by means of its trunk line and not by a side line, as had been originally planned.

The cessation of construction work for more than five years was undoubtedly caused by the company's financial weakness. To obtain funds in Germany was obviously out of the question. The English, French and Russian Governments, on the other hand, were co-operating in the adoption of a joint decision to insist firmly upon the "internationalization" of this important system, and the first two had made it known openly that loans for the construction of the road made in their respective countries were to be contingent upon an equal participation of the four interested powers. But this solution of her difficulties found Germany in an altogether unreceptive frame of mind, and efforts were exerted by all her financial institutions in an endeavour to secure the necessary credits without impairing the decidedly national character of the enterprise.

One cannot pass on at this juncture without dwelling upon the admirable co-operation of the German Government with the efforts of the country to attain supremacy in mundane commercial relations. It may be said, in truth, that, more than in any other country in the world and despite any alleged assumptions of arbitrary power on the part of those in authority, as is often attributed to German officials, Germany is the country in which all government institutions further public interests at home or abroad in the most efficient manner. This state of affairs is strikingly conspicuous in the unremitting support accorded to those engaged in foreign trade by the diplomatic and consular bodies. This active partnership may be taken as constituting a far more powerful factor in that nation's recent acquisition of a large portion of the world's trade than all its individual enterprise put together may ever hope to become.

Perhaps no better result of such concerted action has ever been attained by the Germans than in their ability to finance the balance of this great railroad scheme, as shown by the incorporation of the Glarus syndicate at Glarus, in Switzerland, about two years ago under the auspices of the Deutsche Bank. This syndicate, "Die Gesellschaft für die Bau der Eisenbahnen in der Turkei," has been formed principally with French capital transferred to Switzerland in the apprehension of impending income-tax legislation in France. Its immediate purpose was the undertaking of construction on four additional sections of the Bagdad road. A part of this work will be carried on in that region of heavy uplifts known as the Tauric range, and will involve engineering problems of considerable magnitude. The total cost of construction of these four sections has been estimated at $60,000,000, or an outlay of $71,500 per kilometre.

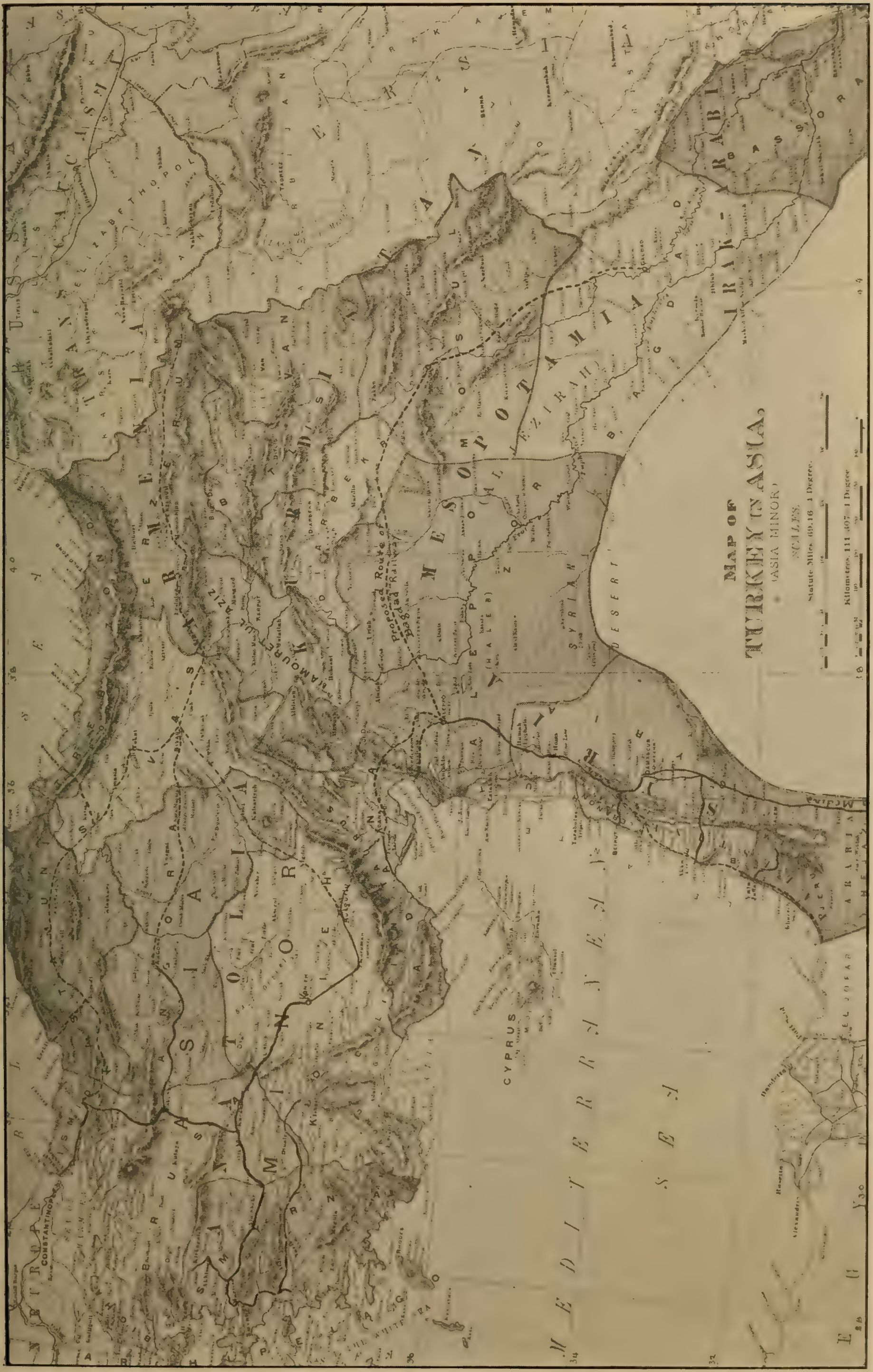
It was intended that work should begin simultaneously at four principal points—namely, from Bulgurlu, the terminal of the first section; from Adana, the terminal of the Mersina-Adana Railway, a line acquired in recent years by the Bagdad Railway Company; from Amanus, and from Aleppo. In May, 1910, operations were undertaken at the first of the points named above, about 100 kilometres being under construction at the present writing. It is surmised that 40 kilometres will soon be ready for traffic beyond Bulgurlu station.

The material employed is almost entirely of German manufacture and includes the latest German steel rails and steel ties. It is freighted from German points of shipment to either Constantinople or to Mersina, on the Mediterranean. That destined for the Taurus sections is sent to the capital, whence it is directed overland to Bulgurlu and destination. The balance to be used in the construction of the track traversing the Cilician plains and extending to the southeast is landed at Mersina and hauled over the Mersina-Adana Railroad.

About 5,000 men are stated to be employed in the actual construction work, mostly Turks and Kurds. But hundreds of labourers of other nationalities are also engaged wherever labour is scarce. These men get, on an average, about 15 piasters a day, or $0.66, although good workmen are paid as high as $0.75 daily. It is expected that all of the preliminary operations will be completed in the course of the next four years and that the new portions of the road will be open to traffic by 1915.

### THE HEDJAZ RAILROAD

This narrow gauge railway starts from the town of Damascus, and has the holy town of Mecca as its objective point. It will thus cover a distance of 1,750 kilometres. By far the greater portion of the line has been constructed, and the road is now regularly operated on the 1,500 kilometres intervening between Damascus and Medina. The financing of this enterprise has been unparalleled in the annals of railroad building. The avowed intent of the construction was to afford primarily a convenient way of traveling to the 225,000 pilgrims who, it is computed, come every year from all corners of the Mohammedan world, and at a cost of $250 per head, to worship at the Kaba'a. It was



MAP OF TURKEY IN ASIA, SHOWING RAILWAYS IN OPERATION IN SOLID LINES, AND PROJECTED ROUTES IN DOTTED LINES estimated that a $50 round trip rate would be sufficient to ensure the financial stability of the undertaking. Money was provided for the construction of the road by appeals made to the religious feelings of the 250,000,000 Mohammedans scattered in widely separated regions of the globe, and their voluntary contributions to this pious undertaking was besought. So successfully did this scheme work that $14,000,000 were soon collected, and for a time about $12,000,000 were contributed annually by the faithful. This operation involved no responsibility whatever to the promoters, headed by Abdul Hamid, the former Sultan of Turkey, inasmuch as all these funds were bestowed in the form of donations. Thus the road had no shareholders and no bonded indebtedness, its capital being spontaneously wiped off.

Labour costs called for no additional expenditures, as the men were drawn from the ranks of the army and no extra pay was awarded them for manual labour on the line. Their only supplementary remuneration for this work consisted in their liberation from military service after expiration of two-thirds of their time. With this sole inducement in sight volunteers were numerous, and at no time was there felt any difficulty in getting all the labour required.

The management was entrusted to the Imperial Hedjaz Railway Commission appointed in 1900 and the construction of the line turned over to army engineers. It must be said that the latter attained remarkable results in the face of such difficulties as the handling of men who were altogether inexperienced in this kind of work, as well as the necessity of carrying on operations in a country infested by hostile Bedouin tribes aware of the impending loss of their secular freedom through the advent of steam engines rolling over steel-bound roadbeds.

By the middle of 1905, 600 kilometres had been completed, an average of 120 kilometres a year. Since then work was pushed with increasing rapidity. By September 1, 1907, 572 additional kilometres were open to traffic, and by November, 1908, 300 kilometres more were ready to support the weight of engines and cars, a record advance of almost 1 kilometre daily. This showing compares very favourably with any made elsewhere in the light of the numerous obstacles inherent to the geographic conditions prevaling in the country traversed. Among the many technical problems with which the builders were confronted was that of the overcoming of sand dunes. These shifting piles of very fine siliceous material form one of the most conspicuous features of the topography of the Arabian desert. Contrary to all expectations, however, they did not materially retard construction, and such sand hills that could not be avoided were simply used, as it was found that where their dimensions precluded removal it was quite safe to ride over them.

The religious character of the undertaking is well evinced by the fact that each train carries a mosque-wagon, wherein pilgrims are enabled to perform their devotions in the course of the journey to the sacred cities. Externally, the praying carriage is distinguished from the others only by means of a diminutive minaret 6.5 feet high. The interior is fitted out, according to current religious customs, with carpets on the floor and suitably framed Koranic verses in letters of gold on the walls. The direction of Mecca is indicated by a map at one end of the car, thus enabling the faithful to orient themselves when engaged in their prayers.

### NEW LINES PROJECTED

Immediately after the promulgation of the constitution in 1908 efforts were made by the new government to promote activity in the matter of building new railways throughout the country. Late in the course of that same year a report on the more important public works, some in the course of construction, others in the stage of preliminary investigation, was sent by the competent department to the Grand Vizir. This document included a list of railroad connections which in the estimation of the government authorities were desirable. It cannot be expected that all the lines shown in that statement will be built without ulterior modifications. The chief value of such a compilation, however, lies in the possibility of its affording an authoritative guide to an enumeration of railroad concessions which the government is disposed to grant, either singly or in groups. As such, it is reproduced as follows:

TURKEY IN EUROPE

| Towns Between Which Railroad Connections Are Desired. | Kilometric Distance Intervening. |
|---|---|
| Rodosto-Moradli | 40 |
| Demir Hissar-Djoumaibala | 107 |
| Drama-Cavalla | 32 |
| Yanina-Sarandos | 78 |
| Florina-Durazzos | 270 |
| Papri-Elbassan | 14 |
| Karaferia-Trapezika-Kozana-Yanina | 280 |
| Gabres-Trapezika | 56 |
| Babaeski-Kirkilise | 45 |
| Monastir-Perlepe | 14 |
| Kirkilise to Bulgarian frontier | 45 |
| Tren-Lake Presbe | 10 |
| Nichavec-Okrida Lake | 17 |
| Topsin-Vardar | 4 |
| Mirdarscutari-Lutchin (with branches to Ipek and Djakova) | 310 |
| Komanova-Bulgarian frontier | 78 |
| Ghida-Platamona (Greek lines junction). | 90 |
| Mitrovitza-Novibazar-Ouvatz | 230 |
| Total kms | 1,720 |

TURKEY IN ASIA

| Towns Between Which Railroad Connections Are Desired. | Kilometric Distance Intervening. |
|---|---|
| Panderma-Soma | 190 |
| Samsoun-Sivas and branch lines | 434 |
| Angora-Yozghat-Sivas | 408 |
| Sivas-Erzerum (via Sarikli) | 542 |
| Sarikli-Enghine-Kharput-Diarbekir | 390 |
| Diarbekir-Bitlis-Lake Van | 250 |
| Eregli (on Bagdad Ry. line)-Nigde-Cesarea | 187 |
| Cesarea-Sivas | 204 |
| Rayak-Egyptian frontier | 385 |
| Helif-Bagdad (via Sadidije) | 645 |
| Hanikine-Sadidije | 120 |
| Bagdad-Nedjef | 175 |
| Trebizond or Tireboli-Erzerum | 380 |
| Erzerum-Bayazid | 360 |
| Nedjef-Zubeir-Bassorah | 410 |
| Zubeir-Persian Gulf | 110 |
| Harran-Ourfa | 30 |
| Adabazar-Hafsa and branches to Eregli. | 170 |
| Diarbekir-Ourfa | 690 |
| Tripoli-Kattine | 100 |
| Mecca-Djedda | 75 |
| Mecca-Medina | 470 |
| Mecca-Sanaa | 960 |
| Sanaa-Red Sea | 260 |
| Total kms | 7,945 |

The eventual building of these lines will allow Turkey the opportunity of including within its territory some of the most important right of ways existing in the whole world. Reference has already been made in these lines to the value of the Bagdad Railway considered as a connecting link between Europe and Asia. Another lengthy stretch of spiked steel of equally far-reaching utility will be provided to the civilized world by the construction of the line connecting Rayak and the Egyptian frontier. This section will form part of a system which may be made to afford eventually unbroken rail connections between any European point and the Cape of Good Hope via Constantinople, Aleppo and Cairo.

Some of the connections tabulated above may be grouped together so as to form very important systems, and foreign capitalists are at the present writing investigating the subject of their future realization. English financiers have lately begun considering once more the matter of connecting Damascus with the ancient town of Hit, on the Euphrates. The vast irrigation scheme contemplated for the fertile valley of Mesopotamia has been the prime mover of this revival of interest in a project that had passionately attracted British public opinion some forty years ago.

It is claimed that the construction of a line between the two towns would cost much less than the paralleling southern portion of the Bagdad Railway, while affording the same conveniences. This difference is chiefly due to the necessity of heavy engineering works required by the latter line, whereas the country between Damascus and Hit is principally a flat, desertic plain, where very little grading would have to be provided. It has been roughly estimated on the basis of work done in other sections of the country that the 650 kilometres between these two terminals could be graded and steelclad at a total cost of $8,000,000, or about $12,300 per kilometre.

French interests, on the other hand,

have secured the concession of the Tripoli-to-Homs line. The importance of this grant may be inferred after inspection of the map, where those Syrian regions to which it will afford an outlet to the sea may be seen, as well as the vast hinterland made up by the eastern section of the vilayet of Aleppo, which it will similarly benefit.

Steps are also being taken to provide the important southern sections of Arabia with railroad facilities and thus divert into Turkish territory the large trade with the interior passing through Aden. Here, too, have French capitalists taken the matter into hand, and a party of their engineers began a survey of the proposed right of way between Sana'a and the Red Sea late in 1909 and continued their labours until April, 1910. It was subsequently reported that they had decided on a seaboard terminal at Gibanah, about 16 kilometres north of Hodeida, and that their recommendations involved a line of about 240 kilometres in length, which would be made to pass through Obal, Sanfur, Suk-el-Sept, and finally attain Sana'a. The estimated cost of the lines was placed at $10,000,000, or $41,700 per kilometre approximately, and it was expected that certain of its sections would present serious technical difficulties, especially those beyond Suk-el-Sept, owing to a difference of 1,950 metres in altitude between this point and the inland terminal lying 80 kilometres north of it.

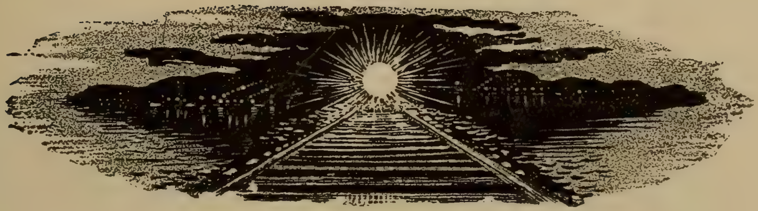
The active help of the Ottoman Government has been freely accorded to all these various schemes, and all the inducements compatible with the actual state of Turkish finances and tending to ensure the future economic stability of the country have been offered to capital. Many departures from the formerly somewhat loose system of granting railroad concessions have also been recently introduced. In conformity with these changes it is believed that the government is not disposed to grant any more subsidies in the form of a kilometric guarantee based on gross receipts. The pernicious influence of this method of aid was reflected by the total absence of a spirit of enterprise on the part of managing committees, aware, as they were, of the possibility of the payments of reasonable dividends to their shareholders, under any circumstances and irrespective of traffic transactions, thanks to such annual revenues from the Turkish Treasury. Still another evil resulting from this system consisted in the utter indifference with which increasing costs of operation were beheld, since the stimulus of greater gain consequent upon reduction of costs did not exist. Thus were Turkish finances submitted to altogether unnecessary depletion from this source alone, and the inadequacy of the method soon dawned on the minds of the abler men lately in power.

A radical change in this direction must be expected hereafter, and it is foreseen that the future incentives to railroad building in Turkey will be based on sounder lines, and will consist especially of tangible governmental co-operation leading to the development of the natural resources of the regions about to be traversed by steel tracks, and thus ensure permanency of the industrial undertakings by forcing production of profitable freight along the location of these future railroads.

The development of the country's mineral resources assumes importance in this connection, inasmuch as it is expected that ore traffic will contribute materially to the prosperity of railroads, both in European and Asiatic Turkey. What is known so far about the geology of the Empire is indicative of the existence of large mineralized areas, and, to judge from occurrences in other regions of the globe similarly benefited, there is no reason why the transportation of ore from inland to seaboard shipping points at first and to smelters later on in the growth of the mining industry should not constitute a high percentage of the total railroad traffic eventually to be handled. It may be interesting to note that in Mexico, a country which is heavily mineralized in like manner, the ore freight on one of the trunk lines attained 40 per cent. of the total tonnage entrusted to its care. This case is cited here merely to show how, in certain exceptional regions on the surface of our planet where mineral depositing agencies have been actively at work, the resulting conditions affect the local railroad industry in a highly satisfactory form.

It may be stated here that Asia Minor especially has been favoured by Nature in this respect, and that this, coupled to the knowledge of its agricultural potentialities, will undoubtedly lead to the establishment of highly remunerative railway enterprises in some of these hitherto inaccessible regions of the Asiatic continent.

Note.—Since the above article was prepared it has been publicly announced that a definite agreement has been reached between the Ottoman Government and the Bagdad Railway Company, according to the terms of which the last section of the line, running to the Persian Gulf, will be owned and operated by an Ottoman Company.



# THE PORT OF LIVERPOOL

By **Mark Meredith, M. E. A., M. I. S. A.**

OF all the ports in the world the growth of Liverpool, from a commercial and an engineering standpoint, has been one of phenomenal rapidity. A little more than two centuries ago the port was practically unknown, and though the town was incorporated by King Charles I., it had received charters from John, Henry II. and Henry III. At the time of the civil war it was of little importance, and when Charles I. levied "ship money" charges in 1636 Liverpool was assessed at £25, as against £1,000 for Bristol.

Liverpool owes its position to-day to the process of economic evolution, for its first dock—the earliest attempt ever made at dockization—was begun in the year 1704. Even to-day all tidal data are referred to the level of the sill of this long-ago removed effort at confining water in a dock, and it is a matter for regret that posterity has not done justice to the man Steers, who conceived the idea. Although the Corporation gave the necessary sanction for this dock to be commenced, some London merchants opposed the idea, chiefly those engaged in the cheese trade, for they saw in the construction of the dock an increase in the charges of the port. Their opposition was unsuccessful, and the dock was hurried on. But soon the estimated cost of £6,000 was spent, and in six years £11,000 had been expended on it, and yet £4,000 was needed. So far as can be ascertained, the dock was opened in 1720; it had an area of 1 acre and 2,897 yards. The first docks were vested in the Corporation, and their early development was carried on towards the south of the "pool" from which Liverpool derives its name. In 1788 the King's Dock was opened, and things went smoothly for a few years. Soon, however, the estate was mismanaged, and the merchants clamoured for a share in the control of the docks. After much heart-burning a compromise was effected and eight of the dock ratepayers had seats allotted to them on the Council. In 1824 the appointment of Mr. Jesse Hartley as dock engineer was made, and he occupied this position until 1860. No man has left his mark upon the port to such an extent as this rough-spun North Country engineer. Hartley was quite a genius in dock construction, for under his guidance the estate was gradually moulded into its present form. He built his docks of gray granite, filled in with an hydraulic cement of scarcely less hardness, so that he built more for eternity than time, as his successors found, to their cost, when reconstructing the old docks. Since 1720 Liverpool has possessed quite a commodious dock system. In the year 1860 its area was about 50 acres, and the King's Dock, the Salthouse, George's and Queen's quickly followed this date. Between the close of the eighteenth century and the present day it is impossible for us to chronicle all the developments of individual docks, but we can deal in general outline with the main schemes of development. Within the century of the opening of the Old Dock it was necessary to enlarge the docks already stated; to convert the port's first dry dock—the Canning—into a wet dock, and to construct two docks to the north and south of the George's. Between 1830 and 1840 the Clarence, Clarence Half-Tide, Brunswick and Half Tide, Waterloo, Victoria, Trafalgar and Coburg Docks were opened; but still the cry was for more docks, and between 1840 and 1855 the Toxteth, Canning, Albert, Salisbury, Collingwood, Stanley, Nelson and Bramley-Moore Docks, as well as the Wellington, Sandon, Huskisson, Clarence and Wapping Docks and the Manchester Dock, were built. In 1857 came the epoch-making event for the Liverpool docks, when their control passed out of the hands of the Liverpool Corporation and they were invested by Act of Parliament in the hands of a public trust entitled the Mersey Docks and Harbour Board, though of recent years it has been called by the easier name, The Liverpool Port Authority. By this act the docks became their property as from January 1, 1858, and they had their work cut out for them to satisfy the needs of the port's shipping. They had to complete the Birkenhead Docks, on the Cheshire side of the river, and between 1858 and 1872 they more than doubled the area of the docks within the port, whilst the tonnage, which in 1855 was only 4,000,000 tons, was more than 6,574,000 tons in 1873. The next dock extension scheme was a £5,000,000 one, involving the construction of the Brocklebank, Langton, Hornby and Alexandra Docks, thus reaching to the northern and southern limits of the present estate. Thus, then, in a little over 175 years an estate was created containing in its area docks and all the usual port adjuncts, whilst there is now a new dock in course of construction which will be unique in the history of dock engineering, viz.: a combined wet and dry dock more than 1,100 feet in length.

From the facts we have already given as to the progress in dock building it will be seen that if the

VIEW OF LIVERPOOL DOCKS, LOOKING NORTH FROM VICTORIA TOWER, SALISBURY DOCK rate of increase had been maintained the docks would have had to be doubled every twenty years to keep pace with the increasing shipping coming to the port, so that had it been feasible to extend their limits they might have stretched at least fifteen miles north and south of their present limits and yet have been incapable of accommodating all the shipping of the port. The alternative scheme to extension was to make the docks already built more effective, and this has been done by "grouping" them according to the particular requirements of the vessels frequenting them. Thus, the Hornby, Alexandra, Canada, Langton, Huskisson, Sandon and Brocklebank Docks have been set apart entirely for the American and African passenger and goods trades. Two graving docks, measuring in sections each 500 and 448 feet long, have been provided out of the Langton and one 925 feet long out of the Canada Docks, whilst between those at the Langton Dock a 100-ton hydraulic crane has been provided.

The Canada Dock is generally known as the White Star Dock, and the Huskisson Dock and branches as the Cunard Dock, as these are the docks in which the steamers of these lines berth. At the Canada Branch Dock No. 3 a huge coaling crane has been provided for dealing with the largest and heaviest coal wagons, which weigh 30 tons when loaded and 15 tons empty, and a speed of 300 tons per hour can be attained and maintained on this hoist, whilst a recent decision of the Port Authority has provided for a duplicate to be erected alongside. At the next following docks as we proceed southwards—namely, the Nelson, Collingwood, Salisbury, Clarence, Trafalgar and Victoria Docks—accommodation has been set aside for the intermediate cargo boats trading in all parts and for the larger coasting traders. Between the Collingwood and Stanley Docks, but on the east side of the main dock lines of railway—which run from Seaforth, at the northern end of the Dock Estate, to the Dingle, on the south, and have branch lines to the various goods depots alongside the dock road of the railway companies trading to Liverpool—is the Stanley tobacco warehouse, which is the largest in the world. It is of fireproof construction, and is 125 feet high, with a total floor area of about 36 acres. The building consists of a vault quay and twelve fireproof upper floors, and is lighted throughout by electricity and provided with hydraulic lifts and hoists. More than 60,000 casks of tobacco can be stored on its floors without piling, and at one time more than 125,000 hogsheads of tobacco, valued at £25,000,000, were stored in its walls. A little to the eastward of the tobacco warehouse is the wool warehouse, which is to have its accommodation increased by about 25 per cent. Its actual present storage capacity is 88,000 bales of wool, but its working capacity is only about 35,000 bales. The top floor is provided with a roof of the weaving shed type, specially constructed to give a good north light for buyers. Returning to the docks, the Waterloo Docks are surrounded by the Waterloo grain warehouses, which are of fireproof construction and five stories high. Along the three blocks of warehouses there are railway sidings, whilst the whole of the machinery, both inside and outside, is driven by hydraulic power. A belt conveyor is used inside the warehouses for conveying the grain and wheat, etc., stored therein from one part of the building to another. The southeastern block of the Waterloo warehouse has recently been let off to Messrs. Thomas Rigby & Sons for use as a flour mill, and already much milling has been done, and quite cheaply, for the boats come straight to the mill from the open sea, whilst the ground wheat is despatched in railway trucks from the door to destination. For the delivery of grain from the warehouses

MAURETANIA AND LUSITANIA PASSING EACH OTHER IN THE RIVER MERSEY silos have been provided on the dock walls of the warehouses. Proceeding again southwards, the Prince's and its Half-Tide Dock are reached. The former of these has been widened by the projection forward into the dock of a piled structure, 708 feet long and 70 feet wide, on which a single-story brick shed has been erected. The Irish boats are berthed at these docks, and on certain occasions sail therefrom direct to sea. Running parallel to the west side of the Prince's Dock is the Riverside Railway station, commenced in 1894 and opened the same year. This is a commodious building covered by a wrought iron roof of one large span 85 feet in width, and used for the embarkation and landing of passengers to and from Euston for America and Canada. From its design and the tasteful colours used for decoration the station has a light and pleasing appearance, though its total length is 790 feet and it is provided with three platforms, each 770 feet long. Mechanical conveyors are provided for the transit of passengers' boxes and luggage from the station to the steamer waiting alongside the Prince's landing stage, which runs parallel to the station, but nearer the river, and of which we shall say more hereafter. Between the Prince's and the Canning Docks is a space on which two noble buildings have been erected. That on the northern portion of the site, which is really the old George's Docks, is the Royal River Building, whilst the building corresponding to it on the south is the head office of the Port Authority. The former is a skyscraper and the latter is a noble building. The Canning and Canning Half-Tide Docks, on the site of the old dock, follow, and are devoted to the interests of the fishing boats, as well as to the pilot boats owned and maintained by the Port Authority, and to some short sea traders. The Albert and Salthouse Docks are next reached, and extensive warehouses for the storage of general merchandise are provided at the former. Near the Canning Half-Tide Dock is the ice factory of the Riverside Cold Storage Company. The following King's and Queen's Docks have quite recently been entirely reconstructed and remodeled, and commodious sheds, with the usual Liverpool type of roof crane, which permits of vessels being discharged very quickly, have been provided. With the aid of these roof cranes it is possible for a steamer to use its own derricks for discharge into the quay floor of the shed and to utilize the roof crane for discharging into the upper floor, whilst cat's head cranes on the other or road side of the shed enable prompt delivery of goods to be made into railway wagons alongside. The Harrington, Toxteth and Brunswick Docks are next reached, and these are devoted to the larger cargo liners trading to various ports in the world, whilst the Brunswick entrances form the great entrance to the southern system of docks. At the northern part of the estate the Canada and Sandon entrances are the main inlets, and the former are regularly used by the Cunarders *Mauretania* and *Lusitania* when they dock—not always possible, owing to the current of the tides in the Mersey. The next and southernmost dock is the Herculaneum Dock, where coaling appliances have been provided in the shape of quick-tipping hydraulic cranes. The main coaling location on the Liverpool side is situated at the Wellington and Bramley-Moore Docks, where the High Level Coal Railway, connected with the main line system of the Lancashire & Yorkshire Railway, has been provided with seven quick-acting tipping cranes. There are, however, now two kinds of floating barges in use for bunkering direct into the coalholds of steamers, and are much in evidence and request by shipowners who do not wish their ships to dock. These are the Rea transporter and the Clarke coaling tower, and, though a minute descrip-

ROOF CRANES IN USE AT LIVERPOOL DOCKS

tion of their *modus operandi* cannot be given here, it may be said that the principle is that of loading the coal into attendant barge and then tipping it into the bunkers of the steamers by means of bucket conveyors. At the extreme end of the Liverpool estate accommodation has been provided for the petroleum trade, and magazines, hewn out of the solid rock of the cliffs adjoining the south and east side of the Herculaneum Dock, each capable of storing 10,000 barrels of petroleum, have been leased to various parties in the oil trade. There are sixty magazines all together, and each has been provided with a moat, and the doors are 4½ feet above the road level, so that in case of accident the contents will fill the moat.

The docks on the Cheshire side of the river are also included in the port of Liverpool and extend inland for a distance of nearly three miles. The chief of these are the East and West Floats, Wallasey, Morpeth and Alfred Docks, these latter giving access to the whole system, which has a total area of about 9 miles and 263 yards. The trades specially situated at Birkenhead are the grain and cattle, as well as those boats trading to the East, whilst in connection with this latter special Orient expresses are run from various parts of the Great Western Railway's system in connection with the steamers sailing thereto. The foreign cattle trade of the port is chiefly dealt with at the Wallasey Landing Stage and the Birkenhead Foreign Animals Wharf, where there is accommodation for about 6,000 head of cattle and 16,000 sheep. Extensive chill rooms and slaughter houses, capable of accommodating 2,800 carcasses per day, are provided. The refrigerating plant is of the latest pattern, and it is said that this wharf is the most replete in the Kingdom. Another cold storage installation has been provided by the Canadian Pacific Railway Company at their berth at the Sandon Dock, so that the perishable goods brought over in their refrigerating vessels may be loaded on to cold air railway vans without being exposed to the atmosphere, and thus ensure perfect freshness in the food. This store is quite a departure, and the Canadian Pacific Railway has the distinction of being the first in the field. On land belonging to the Port Authority there are several depots at Birkenhead for the storage of petroleum in bulk. The tanks, however, belong to the Anglo-American Oil Company, and have a total capacity of about 18,000 gallons. Grain storage accommodation is provided at the Birkenhead grain and Wallasey warehouses, and which are of similar construction and equipment to the Waterloo warehouses on the Liverpool side of the river. A vast power installation for distributing the energy necessary for the appliances in the grain warehouses is situated in the Tower Building, Birkenhead, this serving the hydraulic cranes and coal hoists, the graving dock and other dock gates and for impounding the water into the great float so as to raise its level when the tides are not of sufficient height to allow the largest vessel to dock safely through the Alfred river entrances. A mile or two further south is the Tranmere Bay Development Company's estate, provided with two large graving docks and fitting-out basins. This property really belongs to the well-known Sheffield firm of Cammell Laird & Co., an amalgamation having been effected some years ago with the shipbuilding firm of Laird, which has been situated at Birkenhead almost from time immemorial. However, under the new régime much is being done to bring back the Mersey its old shipbuilding laurels, and many kinds and sizes of boats for the Admiralty and the merchant marine have already been turned out from the Tranmere yards. Between Tranmere and the Birkenhead Docks are some privately-owned graving docks for the repair of vessels. On the Lancashire side of the river, but far beyond the southernmost docks, is the London & North Western Company's port of Garston, which has within recent years become a rival for Liverpool's smaller steamers, who find they can obtain very considerate treatment at the hands of the railway company, both as regards dues and accommodation. There are three docks—the Old, North, and Stalbridge Docks—and more than 3,000,000 tons of imports and exports are dealt with each year, two-thirds of the total being exports

CANADA GRAVING DOCK, LIVERPOOL

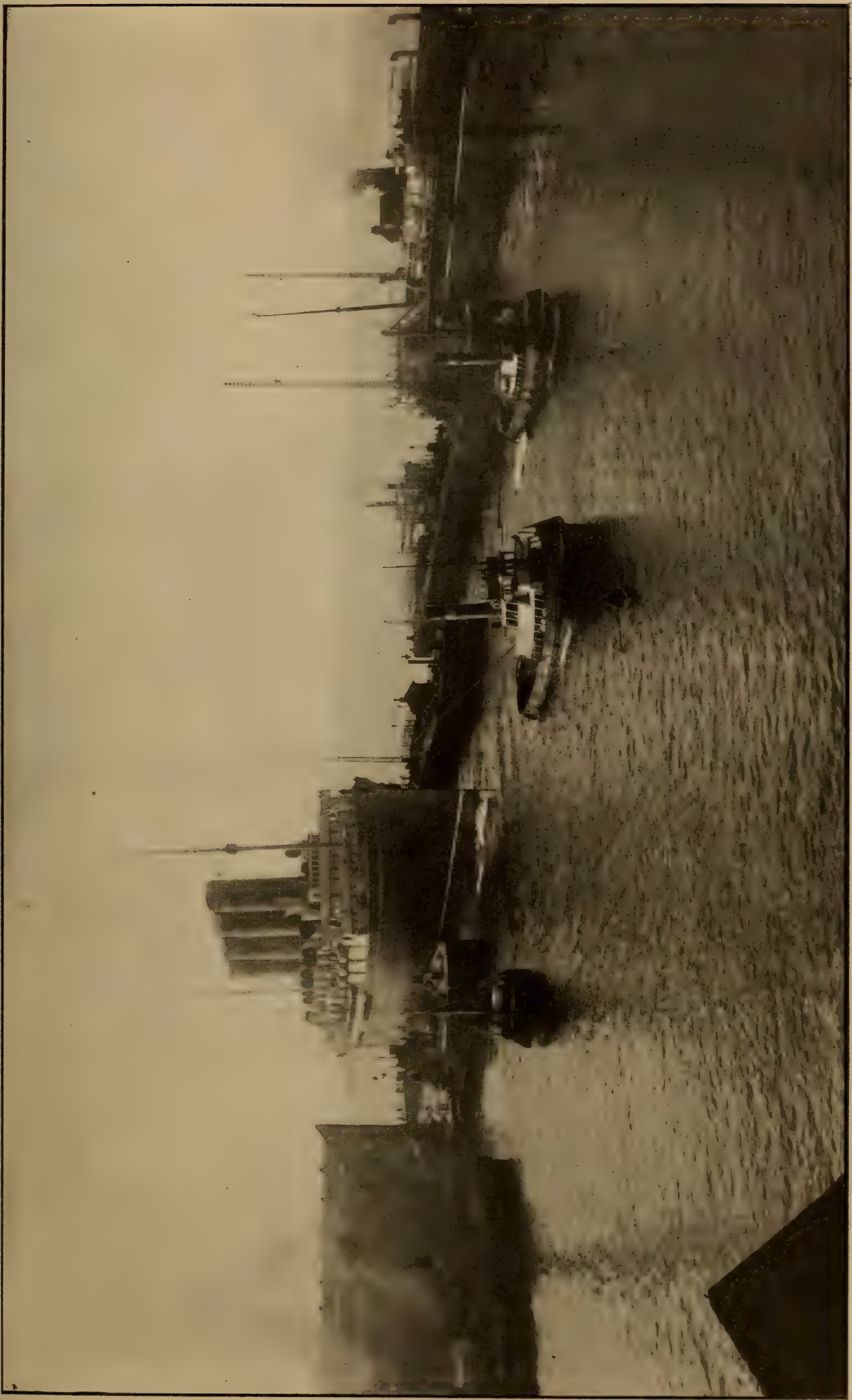
BIRD'S EYE VIEW OF GARSTON DOCKS

and the majority of these being coal.

The marine department of the Port Authority is one which has been an example in one or other of its departments to nearly every port of importance in the world, and its successful operations on the Mersey bar are known to every engineer of the day. Some years previous to 1890 a bar extended across the entrance to the port and only vessels drawing 10 or 11 feet of water could get over it at L. W. O. S. T., so it was decided to make an attempt to dredge this bar. In July, 1890, two ordinary steam hopper barges were fitted with centrifugal pumps, and the suction pipe of one—No. 5—dredger was 18 inches in diameter and the other—No. 7—22 inches. These vessels filled their hoppers in about half an hour, and the result of their work led the Authority to build two boats specially for the work. These, the *Brancker* and *G. B. Crow,* were delivered in 1893 and 1895, and cost about £60,000 each. They are 320 feet long, 46½ feet moulded depth, with a hopper capacity for 30,000 tons. With these dredges as much as 39,000 tons of sand has been dealt with in twenty-four hours and 183,000 in a week of five and one-half days. In 1904 another dredger, called the *Coronation,* was put to work, this vessel being of the twin-screw, self-propelling type, with a hopper capacity for 70,000 cubic feet and capable of being filled in 50 minutes from a depth of 65 feet. The *Coronation* performed her work so successfully that an order was given to Messrs. Ferguson Bros., of Port Glasgow, for another vessel—the *Vulcan*—which was delivered in 1905, being 204 feet long, with a moulded depth of 41 feet, and capable of dredging 10,000 tons an hour from a depth of 56 feet below the water level. The design of this dredger embodies several special features and was prepared by the builders to the special designs of the Port Authority for deep dredging in hard material and close up to the dock walls. The dredger is of the bucket-ladder type, and she has her bucket ladder in advance of her hull for a sufficient distance to enable her to get close up to the dock walls. The latest dredger of the Authority is the *Leviathan,* which was put into commission in the winter of 1910. This vessel is one of the largest in the world, and can dredge 15,000 tons of sand from a depth of 72 feet below the water level in fifty minutes. This dredge was built at the Tranmere Bay works, and has a length of 479 feet, a moulded breadth of 69 feet and a draught of 23 feet, whilst her speed, when fully loaded, approximates 12 knots an hour.

A fleet of some eighty-four vessels helps to maintain Liverpool's marine departments, and the gas buoys and lightships and lighthouses make it the best lighted port in the world. An observatory has been provided on Bidston Hill, where chronometers can be tested for use in any part of the world, whilst the data are often useful in engineering matters and law cases. But of all her maritime facilities the outstanding feature is the Liverpool landing stage, to which reference has already been made. It has been provided specially for the Atlantic passenger traffic, though nearly every passenger ship that enters or leaves the port makes use of it. The whole structure is a floating stage, first built in 1847, but reconstructed after having been destroyed by fire in 1874. It is 2,748 feet long, and has an average width of 80 feet. The main structure is carried on iron pontoons, about 200 in number, each 80 feet wide by 10 feet long and 6 feet deep, arranged at right angles to the length of the stage. On these five box girders are placed longitudinally 4 to 5 feet deep, and above these are placed deck beams of iron running across them about 4 feet from centre to centre. On the top of these ordinary deck planking of two thicknesses is bolted, the whole forming a continuous deck. The stage is held in position by a number of bridges, connected with the shore and stage by swivel joints and also by mooring chains, the shore ends of which are fixed in the river wall. The deck of the stage is about 8 feet

GARSTON DOCK, SHOWING NEW ENTRANCE CHANNEL TO THE STALBRIDGE DOCK



R. M. S. MAURETANIA PASSING THROUGH SANDON ENTRANCE.

above the ordinary water level, and its southern portion is devoted exclusively to the ferry traffic, whilst the northern or Prince's portion is used by the larger ocean-going and Atlantic steamers, for which movable gangways are provided from an elevated deck running along the whole length of the Prince's stage and extending nearly across half its width. The main bridges are 110 feet long, and their incline is practicable for foot passengers at all states of the tide. For cart and vehicular traffic a floating roadway, 55 feet long and 35 feet wide, has been provided. It is formed of sections alternately with a section and a platform, the whole making up a gradually inclined roadway having two cart racks and three passenger racks. At dead low water it has an incline of 1 in 20, and when the tide is higher it is on a level with the roadway. This stage is used annually by about 6,000 vessels, and buildings of all descriptions necessary for the carrying on of business abound on its deck. The stage is used by over 160 vessels per day, and, to enable such vessels as the *Lusitania* and *Mauretania* to come up to it at all states of the tide to land and embark their passengers, a great scheme of dredging has been carried out, and there is now a depth of 70 feet of water available at low water alongside the stage.

At the present day the Liverpool and Birkenhead Docks, directly under the control of the Mersey Docks and Harbour Board, consist of 583 acres of water area and a lineal quayage of 36 miles, whilst its extent on the Lancashire side of the river Mersey is 7¼ miles and inland on the Cheshire side for a distance of 3 miles. The total land area comprised in the estate is 1,677¼ acres, and in it are more than 63 wet docks, 19 dry docks, in addition to four basins, whilst distributed amongst the docks and sheds are over 370 cranes of all descriptions, warehouses for the storage of grain, wool, tobacco and bonded spirits, whilst in addition to the ordinary cranes four barge or floating cranes have been provided and are capable of dealing with loads of from 25 to 100 tons. The value of the dock property is estimated at between £30,000,000 and £40,000,000, and had this been under the control of a private rather than a public administration it is safe to say that a dividend of at least 3½ per centum per annum could be guaran-

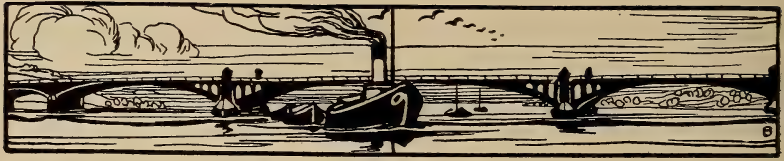
LANDING STAGE AND NEW DOCK BOARD OFFICES, LIVERPOOL

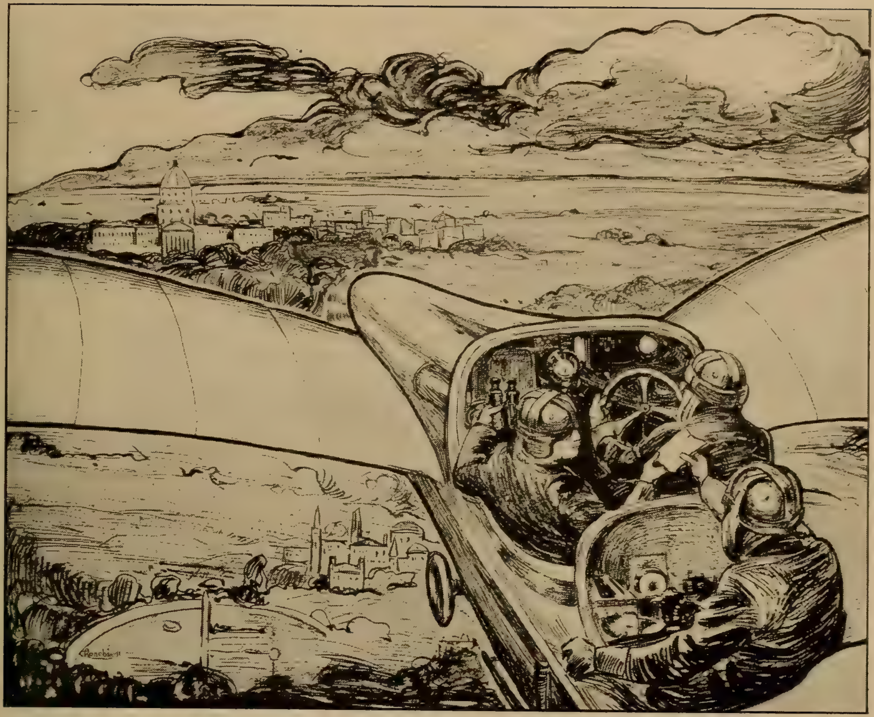
S. S. MAURETANIA AT THE LIVERPOOL LANDING STAGE

teed for as long as the estate lasted, though it is more than probable that 5 or 6 per cent. would be nearer the yield. The expenditure on the estate in repairs and maintenance and new works is a heavy item each year, and generally averages about £1,500,000 per annum, whilst the total amount of revenue to meet this averages £1,700,000. Since the inception of the board in 1857 £30,500,000 has been spent on the docks alone, and, in addition, the board possess many valuable sites at Seaforth and Waterloo and at other places along the banks of the river Mersey, which may at any time be turned into factory sites, whilst on one of the best positions on these frontages they have erected a building in which the whole of their administrative body is housed. Only those whose work necessitates an outside office, such as dock masters, etc., are allowed out of the building, and a kitchen is provided so that the staff can dine on the premises.

Any description of the port of Liverpool would be quite incomplete without a reference to two very enterprising neighbours, who, though not yet rivals with Liverpool, do a great deal in catching the small crumbs of trade which fall from the big port, for Liverpool is too mighty and big to bother with some of the smaller boats and trades, especially the timber trade, which find a home at Garston, or with the shipbuilding, which is located at the Tranmere Bay Development Works of Cammell Laird & Co., Ltd., the well-known Sheffield firm, to which reference has been made above. However, apart from its importance as a trade port, Liverpool is unique as regards its engineering features, as many new and useful methods have had to be invented to deal with the shifting sand banks in the bay and river channels. The remedy for these has been dredging and riveting the face of the more shifty banks, whilst in every respect there have been associated with the port eminent engineers, who may be said to be in the first rank of their profession. The dock lines of railway provide access from the docks and dock sheds to all the various parts of the country, and Liverpool, owing to its facilities and its port custom, offers superior despatch facilities to shipowners over every other port in the world. To-day Liverpool proudly takes the rank of first port, and her success has lain, and still lies, in the fact that she recognizes that she is by no means perfect and is always working to remedy defects as they appear; and she has, what is more important than all, adequate funds at her disposal for carrying out these works.

In the past she has prospered; it rests more with her engineers than her financiers that she prospers in the future. Let them, therefore, have this fact in mind in their daily round, their consultations and their labours.





# THE GREAT TRANSFORMATION

By **Henry Harrison Suplee**

## III.—THE TRANSFORMATION IN WARFARE

> "For I dipt into the future, far as human eye could see,
> Saw the vision of the world, and all the wonder that would be;
>
> Saw the heavens fill with commerce, argosies of magic sails,
> Pilots of the purple twilight, dropping down with costly bales;
>
> Heard the heavens fill with shouting, and there rained a ghastly dew
> From the nations' airy navies, grappling in the central blue;
>
> Far along the world-wide whisper of the south wind rushing warm,
> With the standards of the peoples, plunging thro' the thunder storm;
>
> Till the war drum throbbed no longer and the battle flags were furl'd
> In the Parliament of man, the Federation of the World."
>
> Tennyson, Locksley Hall, 1842.

THERE is probably no application of aerial navigation which has been discussed with more avidity than that which relates to its influence upon warfare; and with reason, since it falls directly in line with the other changes which have already been effected in international conflicts.

Naturally, the studies which have been made of this phase of the subject have fallen largely within the work of military and naval men, and it is also natural to assume, what has been shown to be the fact, that in the great majority of cases these able men have examined it almost wholly along their previous lines of thought and experience, and have regarded the machine in the air either as an auxiliary to land and naval forces, or as an enemy to be encountered in the field. Like other developments in this department of activity, however, the bias of the official has been so great as to permit only a warped and incomplete view of the real questions at issue, and it is probable that the opinions and suggestions of a layman may be nearer the truth than those of men who fail to recognize the wide scope of the new weapon.

It may be desirable to examine some of the former changes which have been effected by civilians in the conduct of warfare, in order to make clear the present situation as regards the actual status of the flying machine.

Ever since the development of the work of the civilian engineer—a development which practically had its present tremendous importance initiated about the beginning of the nineteenth century—it has been evident that the disappearance of the armoured warship and of the fortified city would ultimately arrive in consequence of the increase in human control of the great sources of power in Nature.

Any study of the historical progress of the art of attack and defense, made in a scientific and impartial spirit, such as that by the late Viollet-le-Duc, for example, will reveal the fundamental modifications which invariably followed the successive increases in range of weapons of attack.

In the early period of hand-to-hand conflict a high and thick wall was sufficient protection for defense, and so long as the most powerful projectiles were those thrown by hand, or by the elasticity of wooden or steel bow, the defense of personal armour, of wadding, leather, or metal, was ample. The only points of vantage which could be used to attack a fortification successfully were those within the range of these feeble weapons, and higher points were disregarded if they were only a short distance beyond this range.

The introduction of "villainous saltpetre," however, made the veriest peasant the superior of the man on horseback, and was the beginning of the downfall of that system of personal armour which is now the pride of the museum of antiquities, and thus the scientific man in his laboratory prepared the way for changes which men of slower perception were incapable of perceiving until after the event, when the rest of the world had passed them by, leaving them to bring up a tardy rear. Cervantes, with his acute vision, saw what was coming, and put into the mouth of his hero words which sound very much like some which the writer has but recently heard uttered by military men of the present day:

"Blessed be those happy ages that were strangers to the dreadful fury of these devilish instruments of artillery, whose inventor I am satisfied is now in hell, receiving the reward of his cursed invention, which is the cause that very often a cowardly, base hand takes away the life of the bravest gentleman; and that in the midst of that vigour and resolution which animates and inflames the bold a chance bullet (shot, perhaps, by one who fled and was frightened by the very flash the mischievous piece gave when it went off), coming nobody knows how or from whence, in a moment puts a period to the brave designs and life of one that deserved to have survived many years."—*Cervantes, Don Quixote, Book IV., Chap.* 11.

As soon as the first crude fire artillery came into use it rendered obsolete all fortifications which could be dominated by the surrounding heights which the improved weapons brought within range. Higher walls had to be built, and the design had to be so modified as to provide protection, not so much against the assaults of bodies of men at close quarters as against projectiles of increased weight and force, coming from higher points, and thus able to fall behind ordinary defenses. The newer fortifications usually took the form of wider circumvallations, holding the attack of the enemy further away from the vulnerable centre; and an examination of the plans of many of the older cities of Europe will reveal a succession of boulevards or ring streets, much wider than the ordinary streets of the period, and often planted with trees and shrubbery, these indicating with unfailing regularity the lines of the walls of earlier centuries. Thus, at the present time in the case of Paris, for instance, the walls of fifty or sixty years ago find their principal function in defining the limits of cab fares, while the real fortifications consist of a chain of disconnected forts, miles away from the heart of the city, which they protect wholly by their intersecting fire.

The extent to which the development of modern artillery has rendered recent defenses obsolete can only be estimated, since facts in these matters are, naturally, most difficult to obtain; but there are sufficient sources of information to enable some of the limiting conditions to be determined. It is well known that some of the late siege guns tested in Germany have a range, both of altitude and distance, capable of sending a projectile entirely over Mont Blanc. Experiences in connection with the Japanese attack on Port Arthur showed that the importance of the command of the eminence known as 203-metre hill lay almost wholly in the ability which this point of observation gave to the attacking vessels to receive directions for the aim of guns on board the ships, in getting the range and direction of points within the defenses, otherwise invisible to the gunners.

The real element of importance in the development of battleships of the *Dreadnought* and *Super-Dreadnought* types lies very largely in their armament, and the term "all-big-gun" expresses very precisely the main difference between these ships and their predecessors. So far as the influence of these developments appears, it is widely known that the appearance of the new type of battleship rendered previously existing vessels of war almost immediately obsolete, just as the first conflict of ironclads in Hampton Roads in 1862 placed all wooden warships into the superannuated class. Thus the *Times*, commenting upon the results of the fight between the *Monitor* and the *Merrimac*, said: "Whereas we had available for immediate purposes one hundred and forty-nine first-class warships, we have now but two, these two being the *Warrior* and her sister, the *Ironside*. There is not now a ship in the English Navy, apart from these two, that it would not be madness to trust with an engagement with that little *Monitor*."

It is reasonably certain that many land fortifications have been outclassed by the later developments in weapons of attack, and the principal difference between these stationary defenses and their floating contemporaries lies in the circumstance that the defects of the latter become almost immediately apparent to everyone, while the true condition of the latter is necessarily known to but few.

It is true that the question of another engineering factor — namely, speed—has an important influence upon the fighting capacity of a warship, and the speculations as to the effect upon the history of the world if Napoleon had listened to the propositions of Fulton have attracted many naval students. Nevertheless, it must be admitted that defenses, whether afloat or ashore, would be permitted to remain in an unchanged condition for a long time were it not for the fact that the civilian engineer is continually engaged in devising new means of attack, and thus rendering much of the material of defense obsolete long before it is worn out by service.

In the light of these plain teachings of history, it may be permitted to examine briefly the present condition of attack and defense, especially in connection with some important undertaking, both civil and military, now under critical consideration.

Since past history teaches us that the range of weapons of attack has been continually increased, and that the effect of such increase is to outclass older fortifications and render improved and different ones necessary, we must consider the influence which the development of aerial navigation must have along these and similar lines.

Here we find immediately a most important modification, one which, if carried to its ultimate conclusions, must result in an absolute transformation of warfare. Fighting, even with the most powerful and effective machinery and equipment, so long as it is limited to two dimensions, has certain well-defined limitations. There must be a "front," in land operations, the opposing forces facing each other, and necessarily manœuvring for position and range. Increased range of weapons modifies this situation in degree but not in kind, and acts only to extend the scale of operations. The moment the range is transferred to another dimension and the fighting machine is rendered capable of rising thousands of feet in the air, passing out of sight from below, and moving swiftly and accurately in any direction, all idea of a "front" disappears. This fact has been generally overlooked by military men in discussing the situation, and their comments have usually been confined to a consideration of the machine in the air as operating either for or against the land forces below, and not as being absolutely independent of them.

Much ingenuity and large sums of money have been expended in devising weapons for attacking airships, whether of the aeroplane or the dirigible type; but these all presume that the airship willingly places itself in the same part of the country as the weapons by which it is to be attacked. Trials of marksmanship upon a captive machine, detained at a convenient height and position by means of a cable, have been seriously considered, regardless of the fact that such a machine under competent direction would even now have discovered the enemy at such a distance as to enable him to be entirely avoided while yet far beyond range.

The "front" has been converted into a "top," and indefinitely extended in all directions, while the controlling advantages of vision and perception have been placed on but one side.

The consequence of this transformation appears immediately to anyone whose thoughts are not obscured by traditions of military methods of the past. The whole direction of attack is to be shifted, not to the enemy's obsolete forces, but against its responsible directors. The point of immediate attack will surely become the seat of government, and the blow directed against the men who, by their legislative and executive positions, are responsible for the conditions which have made warfare possible.

Until now wars have been declared by civilians, by rulers and legislators, executive authorities under whatever name, and their mandates have been more or less successfully carried out by others, while these responsible individuals have remained securely in peace and comfort behind the lines which form the "front" of their respective armies and navies. The temptation to act under such conditions of combined power and safety has often been too great to be resisted, especially as motives of gain in power, territory or influence indicated the course to be pursued. Under the new state of affairs, however, there will be a great change—one of the greatest and most far-reaching which can well be conceived under the coming transformation. The men who are actually responsible for the existence of warfare will be immediately placed in the posts of greatest personal danger, and probably become the first victims of their own action. Unless the seat of government is transferred to some underground and wholly concealed situation, the immediate result of any declaration of war will mean an attack from above upon the halls of legislation, upon the residences of executives, and upon the marts of commerce and finance. The whole country will be laid open to attack, lying with its face upward, spread out beyond any effective defense, and practically helpless against the hovering enemy.

The extent to which these plain facts yet remain unperceived is seen in connection with some important undertakings, both civil and military, now in progress and under consideration.

One of the most important engineering works now under consideration is undoubtedly the canal which is to connect the Atlantic and Pacific between the two Americas. Repeating the dictum of Hegel, that the seas connect nations and do not separate them, the waterway which is approaching completion at the Isthmus of Panama must, naturally, take its place as one of the great structures devoted to the use and convenience of man, contributing to the increase in the wealth and brotherhood of nations.

It has been suggested, in view of the definite and approaching completion of this great undertaking, that the time has come to consider the protection of the canal against attack by a hostile power, and its fortification has been advocated and even urged by the highest authority.

That such fortification is either necessary or desirable is a matter for discussion; but, leaving such questions for the statesman, it remains for the engineer to consider whether it is even practicable.

To examine this phase of the subject intelligently demands a critical study of the means by which the canal may be attacked, not only in the light of the methods immediately available, but of those which may reasonably be expected by the year 1915, and for a period of at least ten years thereafter as well. It need not be assumed that an attack would come at once, and, should it come later, it would be made with later weapons.

Since past history teaches us that the range of weapons of attack has been continuously increased, and that the effect of such increase is to outclass older fortifications and render improved and different ones necessary, it is essential to consider the weapons of attack to which the canal works may be exposed, not only at the present time, but during the time for which the proposed fortifications may reasonably be expected to serve. This should include a consideration of the points which are especially vulnerable, as well as those against which attack might be expected to be first directed.

The vulnerable points are doubtless the locks, upon the uninterrupted action of which the entire service of the canal must depend, while the first points of attack would naturally be the terminals. We say naturally, simply because the terminals are the points which would first occur to the ordinary politician advocating a system of fortification based upon precedents already becoming obsolete and certain to be so before the year 1915. The real points of attack will not be limited by location, since the entire route of the canal lies bare and exposed to the present weapons of nearly every civilized nation, and will continue to be so, in spite of any fortifications which can be constructed for many years to come.

Plainly speaking, the attack upon the canal, if attack is to be permitted, will come from above, from the air, through which, even now, there are sufficient weapons in readiness to insure its destruction, and in which, in the few remaining years, there will be even more powerful and more numerous engines of destruction ready for its control awaiting opportunity. *Dreadnoughts* and *Super-Dreadnoughts* will lie helpless and inert along the coast, while the key to the situation will be applied inland and overhead, if statesmen and the governments which they are attempting to guide allow the opportunity for neutralization to escape them.

The nations interested in the maintenance of an unobstructed waterway between the oceans are few in number and controlling in importance. It is wholly within their power so to outlaw any country which menaces the canal that the mere hint of such a thing would become unthinkable. The complete financial, commercial and intercommunicational outlawry which these nations are in a position to enforce would suffice to give a protection which fortifications and battleships could never provide for this exposed strip of waterway, locks, power houses and harbours against the aerial weapons already available for its attack. The range of modern artillery has become too great, and superficial defense is already impracticable. The only real method of fortifying the canal is the moral one, a method which is all the more powerful because of its continually increasing importance in all other parts of the world.

What is true of the canal is true of all other vulnerable parts of the world. Every great city, every financial centre, every point of importance hitherto considered safe because of its remote and protected situation, has unconsciously become broadly exposed to the new weapons of attack, and all former methods of defense have already become negligible. The direction of possible attack cannot be predicted, since all points are now equally vulnerable and equally impracticable of defense.

It is possible that there will be a certain sluggishness of perception of the full meaning of this immense transformation, just as there was in mediæval times with respect to the effect of the introduction of gunpowder upon personal metallic armour. For more than a hundred years after the first crude firearms were introduced the wearers of clumsy pieces of smith work continued to persist in their adherence to ancient methods. It can hardly be possible, however, that existing military methods will continue long after the first real conflict has demonstrated the childishness of a continuance of such customs. Far more probable is it that no actual demonstration will be necessary, but that a full acceptance of the situation will lead to an abandonment of the whole mass of military and naval precedents, as being based upon conditions which belong to an irrevocable past.

It has been said, in a recent discussion of naval engineers, that the result of the development of aerial navigation will mean a transfer of the entire conflict to the air, and that this will mean a change in locality rather than an abolition of warfare. This is possible, but there is a more cheerful outlook, if we may gather any indication from previous developments in civilization.

Every increase in the power of military appliances has been accompanied with an increased realization of responsibility and of the horrors of warfare as a thing of last resort. Already two of the most civilized nations of the earth are considering the practicability of submitting all questions of international differences to arbitration, and this broad view is gradually working its way into the minds of statesmen of other lands.

Such a position is really only an extension to nations of a condition which has already been accepted by individuals for many years, and the man who would endeavour to-day to avenge a personal injury by personal force would be considered as rather lacking in mental equilibrium.

It is not so many years since the

"honour of a gentleman" demanded an appeal to arms, while to-day such an appeal is considered rather as an indication of eligibility to the hospital for the insane, or possibly to the pages of the comic journals. How much of this change is due to progressing civilization and how much to the improvements in deadly weapons we cannot say, but it is evident that changes which have already become controlling for individuals must soon be equally powerful with the nations which those individuals compose.

The transformation which aerial navigation will effect in warfare may, therefore, be summed up as follows:

The exposure of the seats of government to attack will doubtless render executive and legislative bodies less impulsive in permitting warfare to occur, since they will be exposing their own persons to immediate and fatal attack;

The entire existing system of defense, not only of highly fortified places, but also of commercial financial and administrative centres, will be rendered futile and worthless, so that armies and navies will be relegated to the shelf;

Any method of communication upon the surface of the earth, whether by railway, waterway, or sea route, will be fully exposed to destructive attack;

Under such circumstances, it remains for the leading commercial nations of the earth to unite in such concerted action of outlawry against any belligerent nation as will render war out of the question.

(To be continued.)

# VENEZUELA

## ITS RESOURCES AND OPPORTUNITIES AS SEEN BY AN ENGINEER

By **W. H. Booth, F. G. S.**

IN examining the trade possibilities of a country it is desirable to consider, not only the immediate opportunities, but also the future. In any business it is not merely necessary to have the workshops filled with orders to-day; others must be on the books ready for next month, while travelers must be out with new designs to form the basis of orders to be executed perhaps two years hence.

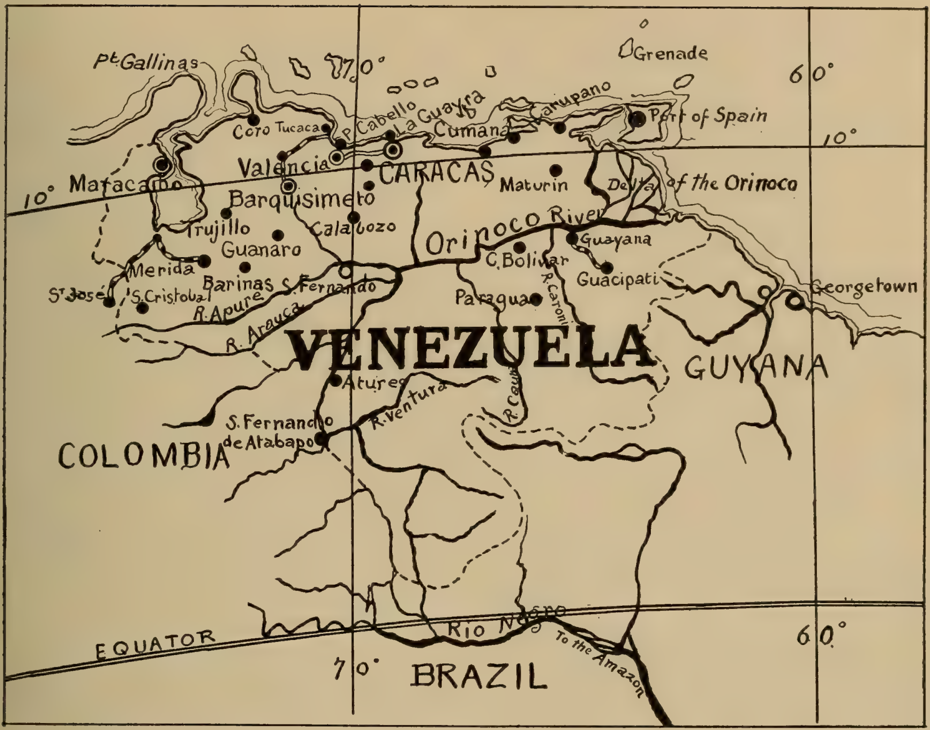
The investigator must look still farther ahead and use both observation and imagination in providing information for use in the far distant future. Many countries now being supplied with goods will, in the course of twenty or fifty years, be producing those goods for themselves, and new markets must be in course of development to replace those which are no longer available.

At the present time there is little scope for the engineering trades in Venezuela. There are only a few miles of railway in the country; the shipping is limited to a few coasting and river steamers; there are but a few miles of tramway and of telegraph and telephone lines, and perhaps one good cotton mill.

There should be a good market for hardware, and a Sheffield machete is most favoured for its excellence; but the principal merchants of the country are Germans, supported by powerful German banking interests, and the bulk of English goods sold is handled by these German houses.

Venezuela is probably thought of as a semi-arid desert, whereas it is a land of rivers and of fertility.

There are three natural divisions of the country—namely, the coastal zone of mountain and valley suited for sugar and agriculture generally; the llanos, or prairie country, which lies between the left bank of the Orinoco and the coastal area. Through the western llanos flow those great tributaries of the Orinoco, the Apure, the Meta, the Portuguesa, Arauca, Vichada, and many others. This is the cattle country *par excellence.* Then, south of the Orinoco and extending deeply into the mysterious unknown, heavily afforested and mountainous region, is the third division, little visited and said of old to possess inhabitants whose heads were between their shoulders. This is the section of perpetual fertility, rich in all manner of products and capable of growing sugar, cotton, rubber, balata, maize, coffee, cocoa, rice, probably tea, bananas and vanilla, cattle and, probably in the hills, sheep of the merino class. The peculiarity of Venezuela—it seems a peculiarity in comparison with Australia—is the perennial joy of running streams. In the rainy season every valley, every cleft between two hills, shows its little river. Many are perennial, and there is no scarcity of water. The Orinoco is the great arterial drain of the major portion of the country. It is always a great river, but during the height of the wet season it rises from 60 to 80 feet above the normal summer level. Roads in Venezuela there are, in a sense, none, except near the chief cities. There are horse tracks by which a traveler finds his way from one flooded river to the next one, and these rivers he must cross, as best he can, on fallen trees, over which he carries his baggage, while his



horses swim. Yet mostly these flooded rivers are small, and would be easily spanned by a few simple rolled steel girders. Bigger rivers could be crossed by chain ferries. There is room for light railways, which could be built, in all save the rails, from the timber and stone alongside the route. In the early stages of development, especially in the back lands, a monorail system, with the crossbar supported by the traction quadrupled, would serve well. Venezuela lacks all these things, and all articles of common use are dear because of this, and excessive tariffs, and other things that might be avoided and eliminated. Of all countries in South America the Argentine Republic seems to have taken first hold on the imagination of the British capitalist. Yet Argentina cannot compare with Venezuela in fertility, climate or rivers, nor is she so rich in minerals; for in Venezuela there are coal, petroleum, iron, copper and gold. Venezuela would yield far better returns than Argentina if helped with capital. Not only is the climate superior, but the locust is not there, nor is there any cattle disease. The so-called wet season is quite a misnomer, for even in the depth of the rainy season, though the rain is a veritable deluge by night, it rarely endures beyond six or seven o'clock in the morning, and rain during the day is neither common nor lasting. A traveler need not hesitate to set out without fear of anything but the flooded rivers, and these could be bridged very cheaply and permanently by girders on concrete piers, easily put up in the dry season; but at present the flooded streams do constitute a serious hindrance to traffic. The traveler must unload his pack animals, offsaddle and swim the animals across the stream, often at some risk of losing them. Trees must be felled to serve as a foot bridge, across which the packs must be carried, and then there is repacking and saddling up when across, so that much time is wasted by each flooded stream that in the dry season is easily crossed without unpacking.

With railways to give easy carriage to the coast there ought to be no real difficulty in exporting a large tonnage of the products of the soil. The government should remove any of the hindrances to this trade which still remain over from the bad days no longer likely to return. Venezuelan frozen meat has already been successfully sold in England, and a fine refrigeration plant is at work in Porto Cabello.

Now Venezuela is but one of many South American republics, and it is one of the most backward. None except Argentina is very busy so far. Venezuela lies directly southwest of Europe, as does Brazil, as well as Argentina. But the other States of this great continent lie upon the Pacific Coast and can be reached only round Cape Horn, a journey of great length. Very soon the Panama Canal will be opened and ships will sail direct to the west coast, and the opening of the canal will have very great influence upon Venezuela, for the northern coast is so near to the line of trade, and openings for commerce will surely arise. This is a most important factor in the situation. Venezuela to-day requires a free navigation of the Orinoco, the regulation of the bar at its mouth, or of the bars at its several mouths, so that the present maximum depth of 15 feet may become 30 feet. The Orinoco has certain rocky obstructions in its course which could be removed by blasting, so as to give a full channel at least as far as Ciudad Bolivar, if not to San Fernando itself, so as to open up the great western llanos to the ocean. The Orinoco is so obviously the great highway of the country and has so many fine tributaries that what is at first required is merely railways to the Orinoco and its tributaries to place the whole country into shipping touch with Europe. The country could do all this easily and the products of

A PALO BRIDGE OF THE TYPE USED TO CROSS SWOLLEN RIVERS, WITH ROPE HAND RAIL

EL MUCHACHO ANDRES, WHO TRAVELED WITH GENERAL TAVAREZ AND THE WRITER TO THE CAURA RIVER AND CANDELARIA

the country would pay for it. The present Government is doing what it can to erase the memory of the Castro régime. Once re-establish confidence, and there is no reason why Venezuela should not find business to occupy several hundred millions sterling of British capital.

With these few diffuse preliminary remarks let us now regard the country with more precision. In the first place, its area lacks but 6,000 of 600,000 square miles, so that it is five times as large as Great Britain and Ireland. It contains but a few beyond 2,500,000 inhabitants, but it should readily support fifty to a hundred million. The coast was sighted by Columbus on his third voyage, in 1498. After becoming independent of Spain, Venezuela separated from Colombia in 1830 and started her somewhat disturbed career as the United States of Venezuela. This period culminated under President Castro, and with his departure a new era has set in. It is realized that there is more to be gained by trade than by bloodshed; but, after all, much of the bloodshed and general disturbance has been but the natural outcome of a latent energy, the development of which has been restrained by unwise legislation and hampering tariffs and monopolies, which there is little doubt will steadily be removed.

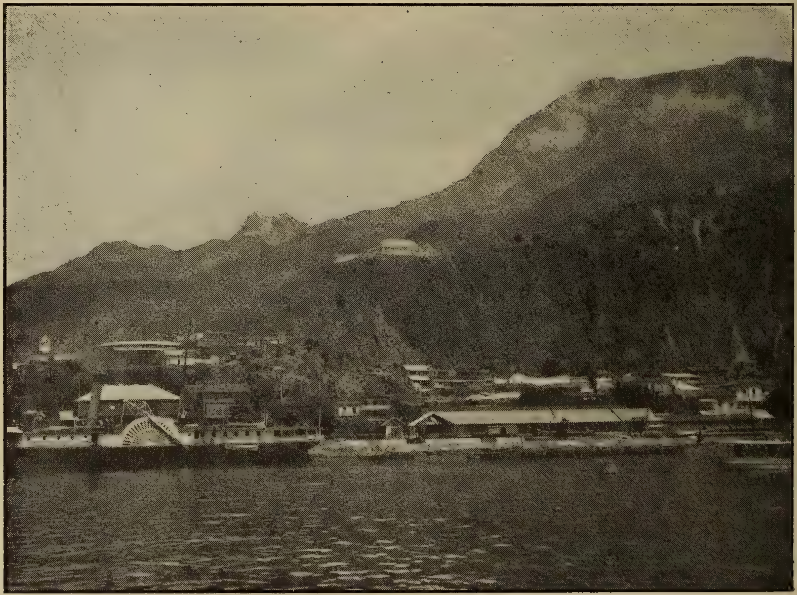
As regards the future, the first thing that should be done is to settle people on the land. The writer has seen a few farms in the country, and what most strikes him is the luxuriant growth which prevails, the density of the maize, cane or banana growth. Given an agricultural population secure of their holdings, the output of the country would be enormous. Settlers can live out of their so-called ground crops. While the grass grows the horse does not starve, for there is always growth. Unlike Canada, there is no long period of winter to place a check on farming. The British Cotton Growers Association would do well to turn their attention to the country. Cotton is a crop that can be planted and gathered within the year, and cotton will always command a market. Some is already grown and consumed by the mills of Caracas. If there are a few

THE CATHEDRAL CARACAS.

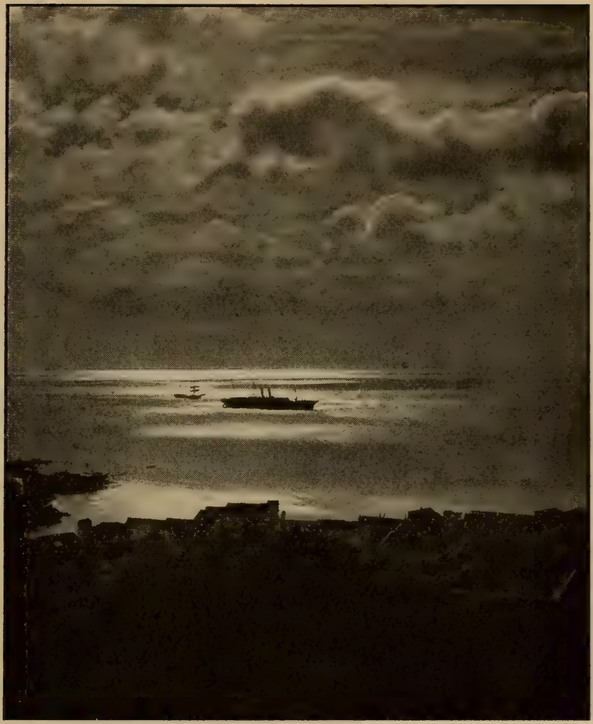
diseases of the cotton plant there is none of the terrible blighting frosts which are so much to be feared in the United States, and there is now so much knowledge of plant parasites and tropical life generally that the farmer is no longer compelled fatalistically to fold his arms and do nothing to stay the depredations of worm, of insect and of fungus.

There are, as stated, not many miles of railway in the country, and this is well illustrated by the curious publication in the daily press of Caracas of the names of all arrivals by the English and German railways. The English railway serves to connect the city of Caracas with its port of La Guayra. La Guayra port is in the hands of an English company, and possesses a jetty or pier enclosing a harbour. Alongside the jetty ships lie. The Caracas-La Guayra Railway has a gauge of 3 feet and traverses a fine mountainous country of red soil by means of winding terraces cut sloping along the hillsides and round the shoulders of mountains and through numerous short tunnels. In a direct distance of about eight miles the locomotive must travel nearly thirty miles, and for an hour after leaving La Guayra the sea still remains close in sight, though many hundreds of feet below the climbing locomotive.

The vertical climb is some 3,000 feet to the sloping plateau on which the city of Caracas is laid out beneath the shade of Silla, the giant hill of 9,000 feet which raises its cloudy summit on the north side of the city. The German line joins Caracas to the other English line, which runs inland from the more westerly port of Puerto Cabello. This line skirts the beautiful country of the valley of Lake Valentia, and its construction shows some fine engineering, and is thought very much to resemble the St. Gothard Railway. In all Venezuela there are not 600 miles of line, but in this short distance are included more than 700 bridges—a single fact that shows the possibilities for bridge builders when real development begins and lines are extended throughout the country



VIEW OF LA GUAYRA, THE PORT OF CARACAS, SHOWING THE FORT ON THE HILL DESCRIBED BY KINGSLEY IN WESTWARD HO; AND THE PADDLE-STEAMER VENEZUELA

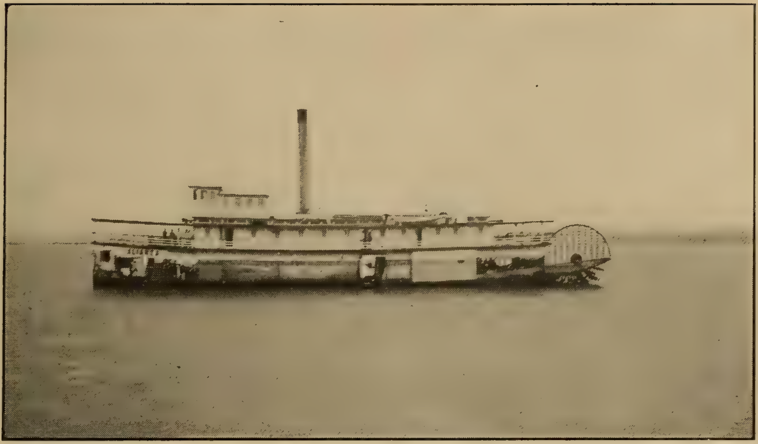


THE ROYAL STEAMER ATRATO AT ST. MICHAELS, AZORES. THE ATRATO RUNS TO TRINIDAD, WHENCE CIUDAD BOLIVAR IS REACHED BY THE STERN-WHEEL STEAMER DELTA

and better managed than some of the existing lines to-day. For much of the country, however, the 4,000 navigable miles of the Orinoco and its tributaries must form the great trade routes in the future. This future, however, as before pointed out, cannot be assured until there is at least one dredged mouth to the Orinoco and until there have been cut away the barrier rocks which, for three weeks in the dry season, reduce the depth in one place to as little as 8 feet. When the river is "up"—which I am assured means 80 feet at Ciudad Bolivar—there is no depth difficulty, except, of course, on the bar. Even so shallow draught a steamer as the *Delta* ploughs mud at the bar of the Macarso Channel, by which the Trinidad trade is usually carried on. The delta of the Orinoco is a strange and weird maze of waters. Even the untutored Indian in his dug-out canoe, familiar with the river on which he lives in naked isolation, will sometimes become lost in the wilderness of criss-cross channels, and is perforce obliged to find some current and allow his frail barque to drift down with it to the ocean, whence he finds his way home again by way of some channel the mouth of which he is able to recognize. The Orinoco is indeed a great living fact. Sweeping along like a great mill race, the stern-wheel boats find it difficult to stem it or to get out of the harrows at Bolivar, and often the current sweeps back the boats, to make a fresh endeavour by way of a less rapid bit of current. The waters are brown with their load of silt, which is steadily filling the Gulf of Paria with mud, and settles in a wide, shallow bar at the many mouths of the river delta, putting out further and further into the Atlantic as the mud filters out in the swamp vegetation whose spreading roots hold the new soil and grow steadily seawards. This delta is not a very habitable spot to-day, but doubtless the day will come when it will form a tract of rich and fertile land. Indians alone can now live in this mosquito maze of swamps, and to this capacity of living there doubtless they owe their lives, for who has cared to evict them from this green wilderness of fertile desert?

Little but bird life presents itself in the delta channels, including the gorgeous scarlet ibis, which is seen in large flocks near the seaward ends of the various channels. Some day the Orinoco will be a second Mississippi, the great highway of a continent. Big as it is, the Amazon has tributaries still larger, and is said to roll to ocean sixfold the watery volume of the Orinoco's great flood. But there are, so far, very few steamboats on the Orinoco, and such as there are are all small stern-wheelers, with a wide paddle-wheel occupying nearly the full breadth of the square stern and driven by a pair of cylinders and long timber rods, steam coming from a boiler fed with green timber and placed forward. The wood station is a frequent and familiar sight on the Orinoco banks. The men in attendance are called up by the hooter of the ship and carry cut timber on board from measured piles stacked on shore close to the water's edge. About some of the stations quite considerable plantations may be seen, including the banana and the inevitable Yuca plant, from which cassava is made. And there is always sugar cane, but the method of extracting the juice is very primitive. A Venezuelan country cane mill consists of an oxmill, a vertical wooden spindle being turned by a long, projecting pole to which the oxen are yoked. There are two vertical wooden rollers geared together by very primitive gears, which possess rough cogs of wood set into the face of the wooden rollers. This and boiling of the expressed juice appears to be the beginning and end of sugar manufacture, and the recovery efficiency is not high. The final result is good enough. It is not white, nor is it very crystalline, but it possesses sweetness out of all comparison with civilized sugar. While still hot and liquid it is cast in wooden moulds of conical shape, round or square in cross-section, and of varying sizes, as the owner fancies. In colour it is like dark honey, and its texture is not unlike that of aged crystallized honey. Why this crude sugar is not sold in London is strange, for it is unequaled in sweetness and unrivaled for coffee, the excellence of Venezuelan coffee being due very much to the mode of preparation of the drink by boiling the coffee and sugar together. The sugar loaf is known as *papelon.* In this industry of sugar alone there should be a great market for machinery, as there should be also in rice milling. Wheat is not much used outside the cities, for the bread of the country is the cassava bread, which is almost universal throughout South America. But wheat should grow well in this country, and Venezuela could probably supply much both to Great Britain and to the United States, the farms of which have been so prodigally exhausted by a system of farm-

A STREET IN CIUDAD BOLIVAR, WITH VIEW OF THE ORINOCO RIVER AND OPPOSITE BANK.

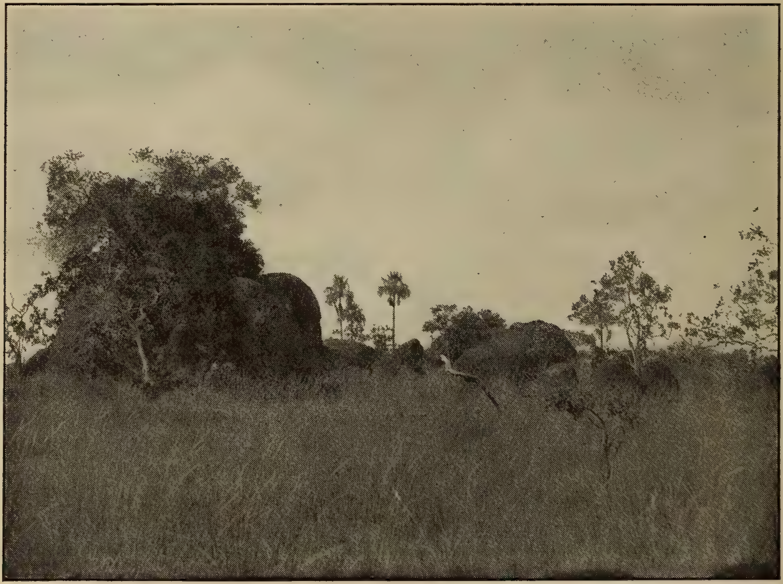


TYPICAL ORINOCO STERN-WHEEL STEAMBOAT, THE ALIANZA.

ing that has broken down the barriers against Canadian wheat, for no longer can the badly farmed great West support the millions of the United States. Canada is farming on the same reckless system to-day. Climatically, Venezuela hardly warrants the term tropical. In the inland flat lands, surrounded, as they are, by mountains, the temperature is not excessive, perhaps because the atmosphere is so mobile. It is rarely quite still, and the Orinoco valley is traversed by a pleasant breeze at almost all seasons. This moderation of heat, to the writer's knowledge, extends as far south as 7 degrees from the equator. Humboldt, who traveled in the country a hundred years ago, appears not to have encountered much difficulty in traveling; but at that time the land was dotted with Jesuit stations. But the expulsion of the Jesuits has left little behind that can help along a traveler. In the wet season he cannot even shoot much game, for the animals are either out of reach beyond some flooded area or they have retired into the depths of the forest, whence they do not require to emerge for water. It was thus that Dr. André came to suffer so much, and this shortness of provisions is a curious and well-recognized fact by those who know anything of the country south of the Orinoco, fertile though it be. But it lacks capital, people, organization and good business methods. Without doubt what the country first needs is better communications from the river into the country. The Orinoco valley is largely granite, and a peculiar feature of the region is the outcrop, at frequent intervals, of great single blocks of the rock or of piles of accumulated boulders wasted by the weather into fantastic and picturesque shapes, like Cornish logans. It is curious to observe that all these granitic outcrops are built up apparently of one block upon another, as though they were once a part of a great mass. What has broken the rock into blocks divided by horizontal and vertical seams? Though a red granite, the exposed surfaces are always black, and the blocks are always wasting more or less. Many of them are seen to be covered with this exfoliation of the surface, which is undoubtedly produced by the fierce heat of the sun, the surface expanding by the heat and often being suddenly quenched by rain, and so breaking up into pebble sand, of which the soil in places is so much composed.

But apart from their picturesqueness, such blocks of stone are available for road making and for railroad ballast. Ties of the best of hardwood can be cut in the forests through or near which the lines must in places pass. The piers for the river bridges can be built from the same granite, and sharp sand is found in every stream; and any line from the river into the interior would, so to speak, build itself, carrying its own rails, cement, bridge girders and supplies generally. A combination railway and settlement scheme, with fair and reasonable general provider business, would quickly develop the country and bring down produce for shipping to other lands. The worst evil of the lowest class of labour in the country districts of Venezuela is the semi-slavery of the people. In debt to the padrone who exploits them, these poor people are paid a nominally fair sort of wage for, let us say, the gathering of rubber, but they are not paid in cash. They are paid in goods, and these goods are charged to them at rates far in advance of even the regular prices, themselves quite sufficiently high. The "Gummers," as the rubber gatherers are called, may be seen toiling laboriously up into the mountains in the Caura district with heavy loads of goods. Year after year they make the same weary pilgrimage, their loads carried by a strap over the forehead and borne on a flat, oval basketwork shield on the shoulders, and they never get out of debt. The "truck" system should be abolished. While it would pay well for any great commercial company to run general stores, the people employed should not be allowed to feel that they must necessarily deal there. The people now are quite alive to the disabilities under which they exist, and are fully able to appreciate the advantages above outlined if only free to exercise their choice.

There are no boats on the smaller rivers, but merely dug-out canoes, hollowed with thick, heavy sides from some great log and then rendered pliable by the lighting of fires in them. The sides are then expanded by driving in successively longer pieces of wood, which are placed aslant across the canoe and the ends driven along the sides until the piece lies straight across the canoe. A longer piece is then simi-



CHARACTERISTIC SMALLER GROUP OF THE BLACKENED RED GRANITE ROCKS, WHICH OUTCROP SO FREQUENTLY IN THE ORINOCO COUNTRY

VIEW DOWN THE RIO CUCHIVERO RIVER, AT LAGUNA LUCIA, SHOWING PART OF ROOFED CANOE

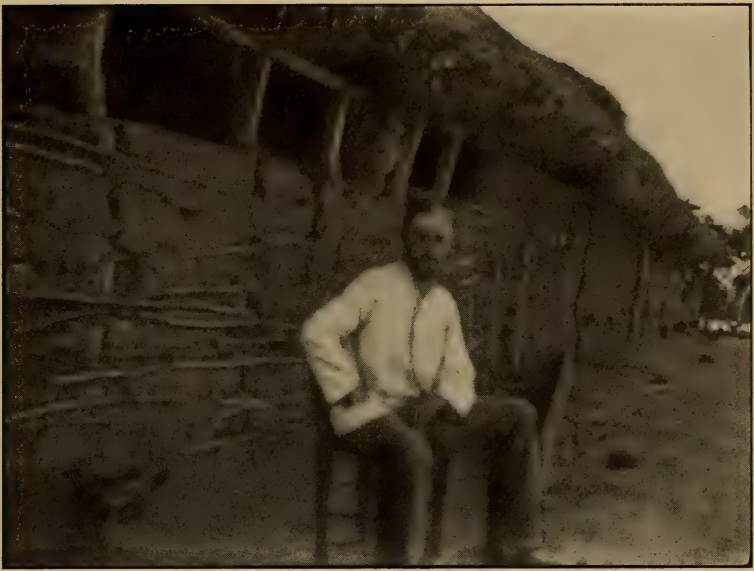
larly driven until the desired width is obtained. On the Cuchivèro river the writer used such a canoe, employing a chief "marinero" and a pair of paddlemen, who stand in the bows and use a flat paddle of sassafras wood with a cross handle like that of a spade. Progress is very slow against the swift current of these flooded rivers. The central part of the canoe is thatched over with palm leaves for several feet, and forms a shelter for baggage and from the sun, though this was not found necessary, in spite of the fact that, on this particular journey, the sun, in its journey south, overtook the traveler and gave no shadow at noon.

Traveling by canoe is very strange; one or the other shore is hugged closely, because of the rapid current in the centre. Coiled in the branches which everywhere hang over the flooded river are to be seen many black and spotted snakes—the poisonous Mapinarles, smaller yellow snakes, an occasional water boa, some of which grow to as much as 7 yards in length, or even more, it is said.

At every few miles there is a small farm or plantation, with a hut at which a traveler is apparently always welcome. As the canoe creeps slowly up-stream an occasional green iguana drops into the water, and monkeys go through gymnastic feats in the lofty trees. In the evening often quite a number of people collect, and it is interesting to hear them discuss rubber and its gathering, or to listen to the weird music of the native guitar. It is all very simple and primitive, yet these people lead poor lives in a surpassingly rich land.

As the country was penetrated further south the people became nearer and nearer to pure Indians in blood, but the same hospitality and honesty characterize the Indians as other people. All live very simple lives in houses almost devoid of furniture. A table and chairs suffice, the roof posts and beams serve from which to sling hammocks. Domestic utensils are few, and, except for a few vessels of metal, are usually gourds or tortoise shells. Windows are not known, for at no time is it sufficiently cold to warrant a closed room. What should at once sell, if supplied cheaply, are graters for Yuca root, and possibly some kind of a screw press in which to press the grated root. Everywhere in Venezuela there meet the eye German goods, such as picture frames, of the tawdry, tinsel, cheap, crude variety which is so characteristic of the lower-class goods of Germany; the people need educating to better goods. Even in well-to-do houses this tawdriness of German goods is often found. Good ironmongery is needed; the saddlery of the country is very poor, and people get along with few wants. It must be remembered that there is no discomfort of cold. A single blanket is good enough for the occasional chill of night. Traveling is laborious if much baggage is taken, and it is a mistake to carry much. A blanket in front of the saddle and a hammock behind are enough, if the food of the country be put up with, such as is found along the Cuchivero river. The writer took a bag with him on this Cuchivero canoe trip, and long journeys require more ample provision. But the traveler who cannot rough it a little, who is afraid of being wet, or who wants to take a midday siesta, who cannot, in fact, accept promptly the lot of a campaigner and leave behind him sartorial fads and fancies, had better stay at home, for he becomes a nuisance to everyone. Let him copy the natives. When they camp by night they sling a netted hammock of light moriche fibre between two trees, the suspension ropes coming out through two sleeves at the end of the mosquitaro. This is not of net, but of fine, closely-woven muslin, and in cross-section it is a sharply peaked Λ, with straight-down sides below the points. At the exterior angle several loops of tape are attached, and a light horizontal stick is run through these. A pair of light, inclined sticks are leaned against the sloping roof and rest on the ground, and are tied to the horizontal sticks where they cross these. The sides of the net are thus held out firmly. The hanging sides lie on the ground and may be held by stones, if necessary; they close off all chance of an entering mosquito. Resting horizontally on the suspension cord of this net, the cord being attached to the same trees as the hammock ropes, are two long, light sticks placed thus ╳. On these is thrown the poncho. This keeps out the rain. A poncho, when of the best quality, is simply a double blue and red blanket with a central diagonal slit, through which the wearer puts his head. The poncho thus rests round his neck and covers him and his horse completely when it rains. Its woolly surface will not take the wet easily, and is soon dried by a shake and by the quickly following sun. In five minutes after the arrival in camp a native will be under cover smoking his cigarette, and will lie dry through a deluge of rain; for if the rain does drive, it flows off the steeply-inclined roof of the mosquito net, whereas a more elaborate arrangement of rubber sheet over a flat-topped calico cover to a mosquitaro would often fail. The Margarita close-woven cotton hammock is also not suitable. It holds water if any gets into it,

GROWTH OF VEGETATION ON TELEGRAPH WIRES AT CARACAS.



HOUSE AT CASUALIDAD, SHOWING ADOBE WALL AND GENERAL CONSTRUCTION

whereas the moriche netted hammock cannot. The moriche hammock—or hamaca, to give it its Indian name—is made from the leaves of the moriche or moritia palm tree. This is the fan palm, so called because of its fan-shaped leaf. This palm delights in damp places, is very picturesque and very useful. The weaving of hammocks from the yarn which is spun from the moriche fibre is a common occupation of the girls of a family. The fibre is prepared by scraping off the green integument of the leaves and combing out the separate fibres. Folded up like a fan, the leaves are the best thatching for a house. They are laid with each short stump of leaf stalk close up to its fellow and bound fast to a longitudinal rafter bar. Down the slope of the roof the next row is about a foot apart. Thus the leaves being about 4 feet long, there are four thicknesses of leaves at every part of the roof. The heaviest rain rarely shows a drop through such a thatch. A house is little else than such a roof standing on round posts, with or without a filling of wattle and daub of red adobe or clay spaded up with dry grass to give it consistency. Not a nail is used. The house timbers and the thatching are all bound together with bejucas—the long, trailing liana, which is used wet, and serves for ropes and many other purposes. The lianas hang in the forests in dangerous festoons from the tops of trees, and the unwary horseman may be easily caught by the neck and slung off his horse by some casual loop as he rides through the twilight of a dense forest. The extremely simple life and unfurnished houses do not extend to the cities. Quite a large amount of excellent furniture is made in Caracas and in Bolivar, and there retail trade travelers who understand Spanish should be sent to study the needs of the country, for there are strange and trivial proclivities for special patterns in different areas of the country which can only be ascertained by actual investigation on the spot. Heavier trade cannot so be fostered. This must follow on capitalistic exploitation of the country, the construction of harbours and railways, and the simultaneous settlement of the land, so as to produce freight for the railways. At present a couple of trains each way per day satisfies the traffic of the Caracas-La Guayra line, as regards passengers, while goods traffic is little, if at all, greater.

Venezuela is, in fact, scarcely touched. The llanos afford pasturage capacity for millions of cattle, yet the first refrigeration works in the country was set to work only last year — 1910 — at the time of the writer's visit to Puerto Cabello. The one flour mill, near La Guayra, was not at work.

With regard to life generally, many parts of the country abound in mosquitos. Across an occasional swamp they would attack in swarms, and clothes would quickly be blood-bespattered by their crushed bodies. But usually it was possible to sit outside in the evening with little or no trouble from the insects, and there is no difficulty in building houses proof against the entry of this annoying pest. On the Panama isthmus the mosquito and his attendant fevers have been nearly abolished. In Venezuela the writer traveled with no precautions except the net, and, later, a pair of very loose gloves of calico. These gloves are no hindrance to the holding of reins, but they effectually baffle the insect by interposing a gap between the hand and the glove through which the insect cannot extend his probe: a sort of air moat too wide to probe across. In its general characteristics the more mountainous area of the southern zone of the country is somewhat peculiar. It consists of a series of areas, from 5,000 to 50,000 acres, apparently surrounded by mountains, as in a pit, but between the mountains there are usually flat river valleys connecting each area with those next to it. These areas are not entirely flat, but may rise 30 to 50 feet above their lowest points. Nor are they hot, as might be imagined, for they seem to receive cool air from the surrounding mountains, which are usually well covered with timber and attract moisture from the atmosphere and roll down cool air to the Savannahs. The level areas have the appearance of having once been areas of water. These, in the progress of ages, have been gradually filled by the wasting of the mountains and drained by the wearing influence on

VIEW OF MOUNTAINS ACROSS COUNTRY FROM HOUSE AT CASUALIDAD

AT STA ROSALEA, SHOWING CALICO MOSQUITO GLOVES, THESE BEING LARGE AND LOOSE ARE A MOST EFFICIENT PROTECTION AGAINST THESE INSECTS

the barriers of the rivers, which owe their waters to the same mountain torrents that first filled the plains to their present level. The soil is often sandy and porous, and water should, therefore, be often found below the surface at no great distance. Where the soil is less fertile the country is good grazing land. In other parts it is composed of a yellow clay. There cotton and sugar and other produce grow. Coffee and rubber are hill products. There are deposits of gold, of copper and of iron. The great El Callao gold mine was found in the St. Felix district, and doubtless will again be opened up and the lode refound. Pitch is found about Lake Maracaibo, in the so-called petroleum belt, that coastal region which lies between about the tenth and eleventh degree of latitude. There is coal in the country, and recently oil has been made the subject of considerable energy, and has been found among other places at Trujillo, near Lake Maracaibo. A fresh cartographical survey of the country is in progress from accurately determined baselines. This department is under the charge of Dr. Aguerrevere, and the maps, which are nearly ready for the engraver, are of excellent quality.

Greater care and control need to be exercised over those who exploit rubber and balata, for these people do not treat the resources of the country at all fairly, cutting down the trees for the sake of present larger gain instead of tapping them in the correct manner. In this way many valuable timber trees are left to rot in the forests, for the balata not only yields its valuable gum, but is an excellent timber tree, and is being cut down before there are facilities for bringing the timber to market.

With so fine a position geographically, resources second to those of no other country, the future of Venezuela cannot fail to be bright. It will be impossible to hold back the country once foreign capital has set in motion the machinery of production. It is to be hoped not only that her statesmen will continue to realize this truth, but that they will promulgate such rules as will enable their country to avoid the error of other countries in recklessly cropping the soil and the forests as though both were inexhaustible.

How little was it imagined twenty years ago that the farm areas of the "great West" were so soon to be exhausted, or that the pine forests would also be almost past the aid of a conserving forestry! Canadians tell us that the same short-sighted policy is cropping the lands of Canada to the same point of exhaustion. Is it not time that South America should step into the breach and, by wiser policy, take up the feeding of the world without inflicting sterility on her soil?

So far, excepting coffee and cocoa, Venezuela has sent abroad comparatively little produce. Cattle are sent to Trinidad, but this trade is not what it was, owing to the neglect of the cattle ranches. Thus, on an estate investigated by the writer, there were said to be 25,000 cattle, but the writer

VIEW OF A WOOD FUEL STATION ON THE BANK OF THE ORINOCO

was unable to find evidence of even 3,000 head, and these of so wild a type, through neglect, as to be of little use except to shoot for their hides. This estate was offered for sale on the basis of 25,000 head. Such careless statements are quite common. *Caveat Emptor* must rule negotiations, for there is a great lack of precision. Thus, the writer was offered a mob of 10,000 cattle, to be delivered opposite a certain point on the Orinoco. Now, "opposite" only means on the other bank to the man who makes the offer. When pinned down in front of a map, he had to point to his place of delivery, and it proved to be 80 miles from the English meaning of opposite, and this 80 miles included three rivers of large size over which only grown cattle could have swam. Even in so small a matter as hiring a boat it is next to impossible to get an inclusive price. The named price will prove to be only the wages of the marineros. The hirer is then asked for so much to cover food for the time, but will find he has to buy as much more. When his voyage is over he finds he has not hired the canoe at all, for the owner now steps up and demands a sum for the use of the canoe. The habit of squeezing out the immediate uttermost applies to the foreign shopkeeping element, as well as to natives. With more and better facilities for trade this habit will doubtless amend itself; and it must be said that if the native is inclined to plunder the traveler, the foreign importer plunders the native, under the excuse of the tariff. True, the customs duty is levied by weight, but even the heavy duty cannot excuse the fanciful prices charged for foreign goods all over the country. Coal is found in Venezuela, but is little worked. But there are some great water-powers. Caracas is lighted and its tramways driven by hydraulic machinery. Yet there are no great rivers near Caracas. The Caroni River, which flows north into the Orinoco near St. Felix, takes a great plunge very near to its junction with the Orinoco. The Rio Caura has several falls of great power along its course. The Cuchivero has falls a few miles higher up the stream than Mantecal, to which point the writer penetrated. The three rivers named all fall into the Orinoco on its right bank, and are comparatively small rivers, the last named being the smallest, but still larger than the Thames, while the Caura is several times bigger and the Caroni still larger. These last two rivers have their rise in a region of dense forests and mountains which has never been fully explored. Humboldt traveled by the Orinoco and discovered that the Casiquaire "canal" was a way to the Rio Negro, a tributary of the Amazon, so that the Amazon and the Orinoco are in free communication. But he did not do much work off the river courses. Dr. André nearly lost his life when attempting to find the sources of the Caura. He left some of his men perforce behind to follow the surviving canoe and sent a rescue expedition to bring them home, but they appear to have wandered off the river and sought a way through the forest, and not a vestige of them has since been found. They perished in the dark forest.

SIGNOR GEN. LAHIDO TAVAREZ, BY RIO EL CAURA AT LA AURORA

But the water-power of the country is not what might be anticipated from the enormous flow of the rivers, for the main streams extend from the far west, unimpeded by rapids, and water-powers are confined to the areas near the mountain sources, especially of the rivers which flow north into the Orinoco. There is plenty of water to be had for irrigation, and many house sites could be located

VIEW UP EL RIO CAURA AT LA AURORA

VIEW OF ROCK OUTSIDE THE PORT OF GUANTA

where a small water-power would be available for farm and house use. The llanos may be somewhat dreary and monotonous to travel in, and there is a singular monotony of green in traveling between the thickly-wooded banks of the Orinoco delta channels. On the main stream glimpses of higher land beyond the wooded banks are often gained. But riding through the varied country to the south of the Orinoco is indeed a charming experience. The sunlit grass or savannahs, surrounded by their circles of mountains, are singularly beautiful; and it is a great contrast to emerge upon one of these bright sunlit expanses from the thick gloom of a tropical forest, through which the traveler splashes and stumbles under and over rotting logs, through muddy swamps and streams, crushing through fern growths, avoiding lianas as they hang from the lofty trees, pressing on through a gloom that becomes awesome and oppressive as the men subside into silence, as they lose the influence of the sunlight, which only occasionally flings a streak of brightness athwart the path. So dense are these forests that the dim light continues unrelieved to within fifty or a hundred feet of where the forest boundary comes sharply and the savannah opens out its full glory of light and a new warmth. Pleasant it is to camp out round a wood fire on some granite knoll, to smoke a quiet pipe with the inevitable and matchless coffee which the men so quickly provide, and to turn in under a frail but watertight cover before the mighty deluge pours down. Venezuela has indeed a special and indescribable charm, which goes far to make up for the many hardships of travel; and one who can rough it will feel sorry to turn his face north again to the Orinoco, there to wait for the next passing stern-wheeler which bears him back to the city.

It is strange to think that so rich a land should be still almost deserted. In the country districts the backwardness exceeds that of the time of Humboldt or Waterton. The natural comfort of life does not make for much striving after the things sought for in harsher climates. Campaigning is not a matter of enduring cold and suffering, so that where the powers have willed it, it has been easy to get up revolutions. Everything points to these being a thing of the past. The Castro régime has gone the way of that of Lopez of Paraguay, never to return, and, fortunately, without having done much harm, as did Lopez. With a continuance of steady government and an elimination of the worst monopolies, of the burdensome tariffs and of the natural obstructions to trade, there ought to be an immense commerce. The soil of Venezuela would pay for railways, roads, bridges, river improvements, and everything that is necessary for the exploitation and conservation of the mining, agricultural, timber and general resources of this fertile land.

In the writer's opinion, the best method of developing this great country would be through the agency of a great chartered company, like that of Rhodesia. It should be on a scale sufficiently large to bear the cost of a police force, to lay railways and improve rivers. By it the land would be settled in suitable farms, and experimental botanical gardens established, after the manner of those in the West Indian islands, where experiments in mango grafting, cacao growing and plant life generally are carried on, and plant diseases are studied and remedies treated. Such a company, unlike that of British South Africa, would soon be able to become dividend-paying, for the cotton plant yields its fibre seven months after planting the seed, and there can be grown maize, sugar and an infinite variety of leguminous plants. Coffee and cacao grow in great profusion, while rubber and balata and vanilla require only conservation and a stop to the present barbarous and wasteful destruction.

The great advantage of a chartered company is that development can proceed under some semblance of commercial and common-sense lines, as distinguished from the inevitable red tape systems which make the failure of governmental methods so certain.

There are some good men in Venezuela who could do excellent work for such a company, men of the calibre of General Lahido Tavarez, who know the country and are capable and successful men.

# COLLIERY EXPLOSIONS; AND THEIR CAUSES

By Percy W. Taylor, M. E.

THAT colliery explosions, accompanied by a large loss of life, have occurred with alarming frequency in the last few years is a regrettable fact. What is the cause and what is the remedy?

As is usual at a time like the present, a period within a few months after an explosion at a colliery (apart from inquest and inquiry reports of the Hulton colliery disaster), there have been many accounts and letters on this matter in the newspapers, some of them, I have noticed, by people not connected with coal mining, but anxious in their way to put things right and offering certain remedies, additional ventilating pit, etc., which they believe would be efficacious to prevent further disasters. However well meaning these efforts are, unless the writers are familiar with the working of coal mines it is impossible for them to realize the great difficulties which are attendant upon the winning and extracting of that useful commodity upon the supply of which the comfort of so many people very largely depends.

To the general public coal-mining is a sealed book; those engaged in the industry in this country are a relatively small proportion of the whole population. The average citizen knows as much or as little about the interior of a coal mine as about the interior of the city of Hong Kong. The newspaper reporter—that walking encyclopedia of general information—is often at fault where mining knowledge is necessary; in reporting an accident he mixes his freshly-learned glossary of mining terms in fine style. But he can hardly be expected to know of what is hidden hundreds of yards below the surface of the earth. The public is not enlightened as to how these accidents occur, and is often very much mystified, finally thinking, perhaps, that those responsible for the safe working of coal mines must not know their business.

I will endeavour to put as plainly as possible a few of the chief factors of danger in coal mines as they apply to explosions.

Probably the chief danger to be contended with is firedamp, or what is commonly called "gas." This firedamp is continually being exuded from the pores of the exposed surfaces, or faces of the coal, when in its natural position underground. This is due to the gas being pent up in the strata; the pressure has been known to be as high as 450 pounds per square inch. When it issues at high pressures it is known as a "blower," its issue being accompanied by a hissing sound, but usually the escape of gas from the coal is imperceptible to ordinary observation.

Coal is the result of decomposed vegetable matter. All coal fields were once huge forests, or, at any rate, are the products of luxuriant vegetation which flourished many millions of years ago. There is abundant proof of this fact by the presence of fossils of trees and plant life in or near the coal seams. The gas is supposed to have been formed during the conversion of the vegetable matter into coal, and owing to the presence of water during the process, water having assisted to form all the stratified series of rocks and shales, and in which class of rock coal is found.

Firedamp, also called methane, is carburetted hydrogen, and is not greatly different in composition from ordinary lighting gas. It is composed of carbon and hydrogen, $CH_4$, one of carbon to four of hydrogen. Its specific gravity is about 0.5, or half the weight of air; therefore, it is found near the roof in mines. In its pure state it is not explosive, but when mixed in certain proportions with air it is violently explosive; 9½ per cent. of gas in the atmosphere forms the most explosive mixture. It has also a poisonous effect upon human beings if continuously inhaled in certain quantities, which can be defined. As has been said, this gas is being constantly emitted from the exposed surfaces of the coal in the mine, and from this fact we get the term "fiery mine." In some mines it is not found, but these cases are generally where the seam is not far from the surface, and all the gas has probably drained away through cracks or faults in the strata. The flow of firedamp is particularly sensitive to varying atmospheric pressures. The volume of a gas varies inversely as the pressure upon it. Thus, a fall in the barometer is accompanied by an influx of gas into the mine roadways, owing to the decreased pressure. The state of the barometer is an indication as to the state of a mine as regards the issue of firedamp, which is affected at exactly the same time as the barometer, though to a much greater degree. A quick fall in the barometer, accompanied by a sudden rise in the thermometer, is the most dangerous time; the drop in exterior pressure causes more gas to be given off, and a rise in the temperature causes the ventilating efficiency to be slightly less. By following certain rules of ventilation the fresh air from the surface is taken round these exposed faces in the mine, and the current produced serves the double purpose of sweeping out the gases (firedamp or other gases) and affording ventilation to the men working at the coal.

Before the colliers go down the pit in the morning an official, called a fireman, goes around to see that the working places are all safe, that the ventilation is in perfect order, and that no gas has accumulated. This examination must be made, according to the special rules in force in the Manchester district, not more than three hours immediately preceding the time the men go to their work. (It is proposed to alter this time to two hours.—Mines Bill, 1911.)

The name fireman originated many years ago when mining was in its primitive stages, and at a period when there was no systematic method of ventilation in mines. Firedamp would collect, and it was the duty of the fireman to go and fire the gas. He would have a damp cloth tied round his head, covering his face as much as possible, and with a torch at the end of a long stick would ignite the gas. By falling flat on his face he would endeavour to avoid the effect of the flame. It will be evident that there were many risks connected with such dangerous practices. At a still later period, but before the use of gunpowder was prohibited in fiery mines as a means of bringing down the coal, the ignition of the gas was a common enough occurrence. Some of the older colliers living to-day, speaking of their experiences thirty to forty years ago, say that they have seen gas ignited in coal mines many a time, and they have "batted" the flame out with their coats or caps. By the use of explosives which are calculated to give no flame, or by using mechanical substitutes for blasting, we do not get such experiences nowadays. Also, naked lights are not allowed on the working "face" in fiery mines, though they are still used in mines not far from the surface, which are not "fiery" and are probably naturally damp.

Another great source of danger in

connection with mine explosions is coal dust. When in a very fine state or powdery form and mixed with or held in suspension in the air, coal dust has been conclusively proved to be highly explosive. The fine dust produced by certain coals is much more inflammable than in others, owing to the presence of a higher percentage of volatile matters. The main haulage roads are the chief source of danger as regards coal dust. When the coal is being taken to the pit bottom in the mine wagons or tubs, as they are called, a considerable amount of dust is scattered about the roads. This is due to the jolting and bumping of the tubs against each other, causing the fine coal to percolate through any holes there may be in the tubs and to the passage of a brisk current of air in the roadway, which blows the dust from the coal in the tubs. Also, fine dust is taken, to some extent, from the working face to the roads by the air current, especially if mechanical coal cutters or conveyors are used. The finest and most dangerous dust collects on the roof, bars and sides of the road. Nowadays a main haulage road will probably last a good number of years—perhaps ten or more—and thus the collection of fine dust, unless some means are taken to deal with it, will become very considerable. It will be obvious that additional ventilating pits, as mentioned at the commencement of this article, would not affect the coal dust question.

The safety lamps used in mines are of many kinds, and are contrivances for keeping the light in the lamp protected or insulated from the outside atmosphere. The principle of practically all these lamps originated with the Davy lamp, invented in 1815 by Sir Humphry Davy. A covering of wire gauze, constructed so that there are 784 apertures to the square inch, forms the chief feature of the lamp. Flame will not pass through such a gauze unless it is heated to redness, and the lamp is so constructed that in case of a big flame inside the lamp, due to it being placed in gas, the whole light is immediately and automatically extinguished. Sufficient air cannot enter the lamp by the intake air passages to keep the flame alight, and it is smothered by the products of its own combustion. The safety lamp is also a good indication of the presence of a small quantity of gas. When testing, the ordinary flame of the lamp is turned down very low, so as to give practically no light at all, and the lamp is slowly lifted to where the presence of gas is suspected. If the gas is present, a blue cap or halo appears above the small flame, and according to the height of the blue cap the percentage of firedamp present can be judged.

As I have pointed out, small ignitions of gas and explosions did occur years ago, and occurred frequently; but then the mines were not far from the surface, and were thus naturally damp, and therefore no collection of dust to continue the explosion was possible. Again, if the mine happened to be dry, the extent of the haulage system was not elaborate; the output at that time from one pit was very small compared to a present-day output, even at a small colliery, and thus there would be very little dust collected in the haulage roads, and there would probably not be much harm done by these small explosions.

The consumption of coal has very greatly increased in the last thirty years. More is used for steamships, factories, workshops and foundries, and also more household coal is used. The mines near the surface are almost worked out, necessitating the working of the lower mines. These are, naturally, hotter and dryer than those above, and are gaseous. By modern machinery the coal can be hauled below ground from greater distances than was possible years ago; thus the roads are much dustier, giving an additional source of possible trouble.

Sufficient ventilation is one of the chief essentials at a colliery. General Rule I of the British Coal Mines Act says: "An adequate amount of ventilation shall be constantly produced in every mine, to dilute and render harmless noxious gases to such an extent that the working places . . . shall be in a fit state for working and passing therein." This has been a much criticised rule. What an "adequate amount" of ventilation is, has, up to now, not been defined in plain figures. However, the recently proposed Mines bill gives a certain standard to be aimed at. Powerful fans cause the air to be circulated round the workings (furnace ventilation is now almost obsolete), and in most cases causes a cool current of air at the coal face. A quantity of gas, large or small, as the case may be, may sometimes accumulate, owing, perhaps, to some temporary difficulty with the ventilation or to a sudden "blower" of gas. If everyone does his duty, the danger is inconsiderable. If the fireman in his morning round, previously alluded to, finds gas, he should fence the place off, stop men going in, and report to his superior official—that is, if he cannot remove the gas immediately by any approved method. If the gas appears whilst the collier is in his working place, he should at once report to the day fireman in his district. The main point is this—no man should work in any "show of gas," and no official can conscientiously allow him to do so.

A defective lamp may cause the gas to be fired, and this may extend to a coal-dust explosion; also, of course, a naked light will fire gas, and yet it is a daily occurrence for men to take matches into the mine. Admittedly this is not for the ostensible purpose of using them in the mine, but owing to inadvertence; men smoke their pipes on the way to the pit, and they require a supply of matches for this purpose. They forget and bring the matches, contrary to law, in the pockets of their clothing into the mine. Searches are conducted at varying periods at most collieries, and it is seldom that a few matches or smoking material will not be found as a result of a search at any large colliery. Apart from a naked light taken into the mine and a defective lamp, there are other ways in which a flame may be produced and thus constitute a danger in mines—sparking from electrical machinery, brake "blocks" igniting by reason of excessive friction, a "blown out" shot, due to explosives being badly applied, or spontaneous combustion of the coal and gob fire. It is alleged by some authorities that the blows from the miner's pick will produce sparks of sufficient temperature to constitute a danger in this respect, though this is very doubtful.

What happens after an explosion of firedamp and coal dust? It is well known to all students of chemistry that when any chemical change occurs light and heat are generally the results, and that gases, when heated, expand more than any other substance. An explosion is really very rapid combustion, which generates heat, a chemical change occurs in the gas, and pressure is created by the rise of temperature. As the gases from the explosion of gas and coal dust expand in a confined space, such as the roads and workings of a coal mine, terrific havoc is caused, owing to the tremendous energy created, which cannot find room to expend itself immediately. Only those who have seen the state of a mine after an explosion can realize the amount of damage done by this force, and which is done in such a short space of time. As the explosion spreads along the roads fresh dust is raised; this explodes in turn, and continues or magnifies the first ignition into one terrific explosion.

The familiar sounds of the life are heard down in the mine, the moving haulage carrying its burden of hundreds of tons of coal to the pit bottom (which represents a large railway junction in miniature), the men and boys all doing their appointed daily tasks, the shouting of orders, perhaps a laugh and a joke or so; then a terrific roar as of the sound of a million demons let loose, or the whirling of a gigantic whirlwind which sweeps all before it, and then silence—the silence which follows devastation and death. Generally the cause of the first ignition can only be conjectured; the old saying that dead men tell no tales is never so true as in these cases.

Added to the havoc and damage wrought by the actual force of the explosion there is the additional danger of the afterdamp to those who survive the blast. The chemical change which occurs when firedamp is exploded is as follows: The carbon in the gas combines with the oxygen in the air and forms carbonic acid gas, and the hydrogen is converted into watery vapour. Carbon and hydrogen also form part of the composition of coal. Ordinary air is composed of four-fifths nitrogen and one-fifth oxygen. The oxygen will be used up in the way above described, leaving the nitrogen free. Nitrogen does not support life, and carbonic acid gas is poisonous, and, therefore, it will be seen that the atmosphere after an explosion is most deadly. If there is not sufficient oxygen to complete combustion, carbon monoxide, a still more dangerous gas, is produced. One-half of one per cent. of this gas is dangerous to life, and in a good number of cases after an explosion a large percentage are killed by its effect. It has the peculiarity of colouring the exposed parts of the bodies of its victims a dusky red, giving a most life-like effect to the bodies when found.

When the news of a big colliery explosion is conveyed to the man in the street he knows vaguely that there is something very much wrong, but only to one with a knowledge of the effects that these gases have on human life, and knowing that all ventilation will probably be shut off, does the news come in its full awfulness. It is true that in some cases the air in a part of the mine may be left pure; but, owing to the stagnation of the ventilation, by reason of the district probably being isolated by falls of roof or other impediments, there is generally a poor chance of rescue.

It is essentially important that rescue parties should be composed of men used to mines, and that no others, however willing and desirous to help, should be allowed in this work. There is as much sense for a man who cannot swim to jump into the water when a person is drowning as for men unacquainted with mines and the gases likely to be met with, going on these rescue expeditions. I believe there have been cases where men unacquainted with mines have rushed into gas and been overcome; but it is indeed a case of misplaced valour, as they constitute an additional danger and a hindrance to the rescue operations. Something can be done by keeping cool and using common sense. A cage containing a canary is indispensable on approaching a mine after an explosion. Canaries and small, warm-blooded animals, such as mice, are—probably because of their extremely delicate organisms—particularly sensitive to carbon monoxide. Thus, a cage containing one or two canaries should always be taken with an advance exploration party; they are affected by minute quantities of this gas a short time before it will affect a human being.

Almost every colliery of any size now has its teams of rescue men, who have been trained at a central rescue station in the use of apparatus by which they can breathe, move about, and work in an irrespirable atmosphere. These devices, invented some thirty years ago, and now brought to a high state of perfection, are of various types. Probably those mostly in use are provided with compressed oxygen in cylinders, the oxygen being turned on and off at will by the wearer of the apparatus. A breathing bag plays an important part in the design, the carbonic acid gas exhaled being absorbed by means of sticks of caustic soda. Teams of men trained in the use of such apparatus were of great service after the recent disaster at Hulton colliery in exploration work and in assisting to clear the working districts of gas.

That all mining men are face to face with a grave and serious danger must be admitted. It would appear in this scientific age that explosions should be a thing of the past. Such disasters as have occurred within the last few years are a standing menace to the whole mining community. Every responsible person engaged in coal mining, the greatest of all industries, should consider this question most seriously and try to become wiser from the lessons of the past, which is knowledge bought so dearly. An ignition of gas, and its consequent explosion, will stir up all the fine inflammable dust, and then the explosion may spread through the whole mine. It is the first ignition of gas or coal dust which must be stopped.

It is essential that all shot-firing during working shifts should not be allowed in fiery mines, as a blown-out shot or otherwise badly charged shot may give the requisite flame to ignite gas or coal dust. It is certain that a blown-out shot (which really represents a charge shot from a gun) stirs up the dust exactly as is required to constitute an explosive atmosphere, and only the flame is then necessary, and this may also be forthcoming, as not all the explosives in use are flameless under every condition.

Is the safety lamp a safe lamp under all conditions and circumstances? It is to be feared that it is not. If such a lamp is stationary in an atmosphere in which a certain percentage of gas is present the flame will lengthen, but there may not be enough gas to cause it to extinguish itself, as before described. If the same even percentage continues, the gauzes and lamp may become red-hot, and then it is no longer a safety lamp. It is not impossible for a lampman, when fitting a lamp together, to make a mistake and send out a defective lamp, by reason of one of its component parts being missing; this is not always discernible by the external examination to which it would afterwards be subjected. A good test would be to pass the lamp through a chamber which contained an explosive mixture. After it had passed the test the lamp could be re-lit again electrically or otherwise.

That "familiarity breeds contempt" is only too true with the underground worker; he is so used to his hazardous calling that he takes unnecessary risks in many cases. He is not as careful of his lamp as he might be. A smashed glass, or a blow from a pick damaging the shield and gauzes or otherwise rendering the lamp unsafe, might result in a great catastrophe. Also, lamps have been wilfully opened in the mine. It is unnecessary to enlarge upon the results which a wilfully exposed lamp flame might occasion.

A scientific and sensible view of the lamp question is a partial solution of the explosion problem. A standard type should be universally used; there are at present too many kinds in use. Whether self-contained portable electric lamps are to supersede the oil or spirit lamp for general use is a matter yet to be decided; they certainly give a much better light than the safety lamp, are safe in an explosive atmosphere, and would be difficult to tamper with; the vacuum being broken, the lamp would be useless. To be unable to test for gas by an electric lamp would be a disadvantage, unless the inspection of the working places were taken over altogether by the firemen and other officials, entrusting them alone with safety lamps. This would probably mean an addition to the number of firemen in most cases. That there is a reformation of some sort needed amongst colliery firemen, taken as a whole, there is not much room to doubt. It is questionable whether 30 per cent. of the total number of firemen acting in the North of England coalfields to-day could enumerate the various gases met with in mines, with their different compositions and weights, and also say how each gas affects human life and the safety lamp. Educate the men in and about mines, and a great factor of danger will be eliminated. In the Coal Mines Bill at present going through Parliament it is stated that, after January 1, 1913, it will be necessary for firemen to possess a certificate as to his competency to test for inflammable gas, etc., etc. This is certainly a step in the right direction.

We have seen in the newspapers a lot of controversy about the introduction of working-men mine inspectors, and, in addition to the present government inspectors, some fresh appointments are to be made. To my mind, the introduction of a class of government inspectors, inferior in education, as regards the science of mining, to the present inspector, will not be of any advantage whatever. An addition in number to the present inspectorate staff is another matter.

The fireman is the permanent underground inspector, appointed by the manager of the mine and paid by the owners, and a great responsibility rests on him. I have heard it argued, and by persons whose training and experience give them a right to an opinion, that the firemen should be appointed through the government, and that his duties should be solely to look after the immediate safety of the district. The contention is that, by having, shall I say, an inspector-fireman to look after a district as regards ventilation and the safety of the men in general, other duties would not be thrust upon him, and that, not being responsible directly or indirectly to the colliery owners, he would be able to exercise an open hand in making reports which might be adverse to the interests of other officials of the mine. The inference is, of course, that by the present system firemen may be influenced, for some reason or other, to allow men to work in unsafe places. Some mines may be worked on these very doubtful lines, but it is very certain that the majority are not, and that true reports are made of the condition of the workings, as it certainly is to the interest of everyone concerned for it to be so. There is sometimes a weak link in a chain, and the few mines that may be looked after on the suspicious grounds above suggested constitute that weak link. If the firemen were to be under the control of the State as regards appointment, etc., it would certainly be at much greater expense than the present system; he would require higher wages, and would be altogether a more important person than at present. All remedies are almost certain to entail more expense and trouble to colliery owners than formerly, and if the present system is at fault a better one must take its place. Though suggestions of various kinds may at first appear too drastic and revolutionary to be practicable, on second thoughts it may seem that fresh ideas are worth contemplating, and that to pay the price is better than to permit the wholesale slaughter which has taken place in the last few years to continue by these terrible explosions so often occurring.

I have not space here to enter into the intricacies of the coal dust problem; the advisability of dustless zones in the mines, treating the roads with chemicals to render coal dust harmless, the sweeping of roads to clear away fine dust, or stone dust being spread about to counteract an explosion of coal dust, or the question of watering the roads periodically with the object of damping the coal dust.

The disposition of the dust in the first case is one of the most important points to be considered, and this can be prevented to a great extent by the adoption of a good type of iron dustproof tub, and, if necessary, with the addition of a lid or covering to them.

It will be apparent, then, from the above matter that, at the present time in the working of a colliery, the risks are greater, the engineering difficulties greater, and the whole business of coal mining more complicated than formerly; and that to keep up the high standard of safety which is the aim of the colliery manager his resources are taxed to the utmost. And if any accident does happen, the manager is held up as the scapegoat, as he is directly responsible for the safety of all above and below ground at a colliery. It may be argued that if the existing conditions of coal mining are so dangerous regarding explosions of gas and coal dust, why are not some extra precautions made obligatory? Something can and will be done in these weighty problems; the question is agitating the minds of some of the leading scientists of the day; but it will be seen that, however careful are the mining engineer and manager at a colliery, and however many precautions they may take as regards safety, any slackness or carelessness on the part of the under officials, or workmen in the mines, may result in disastrous consequences.

# THE WATER SUPPLY OF A GREAT CITY

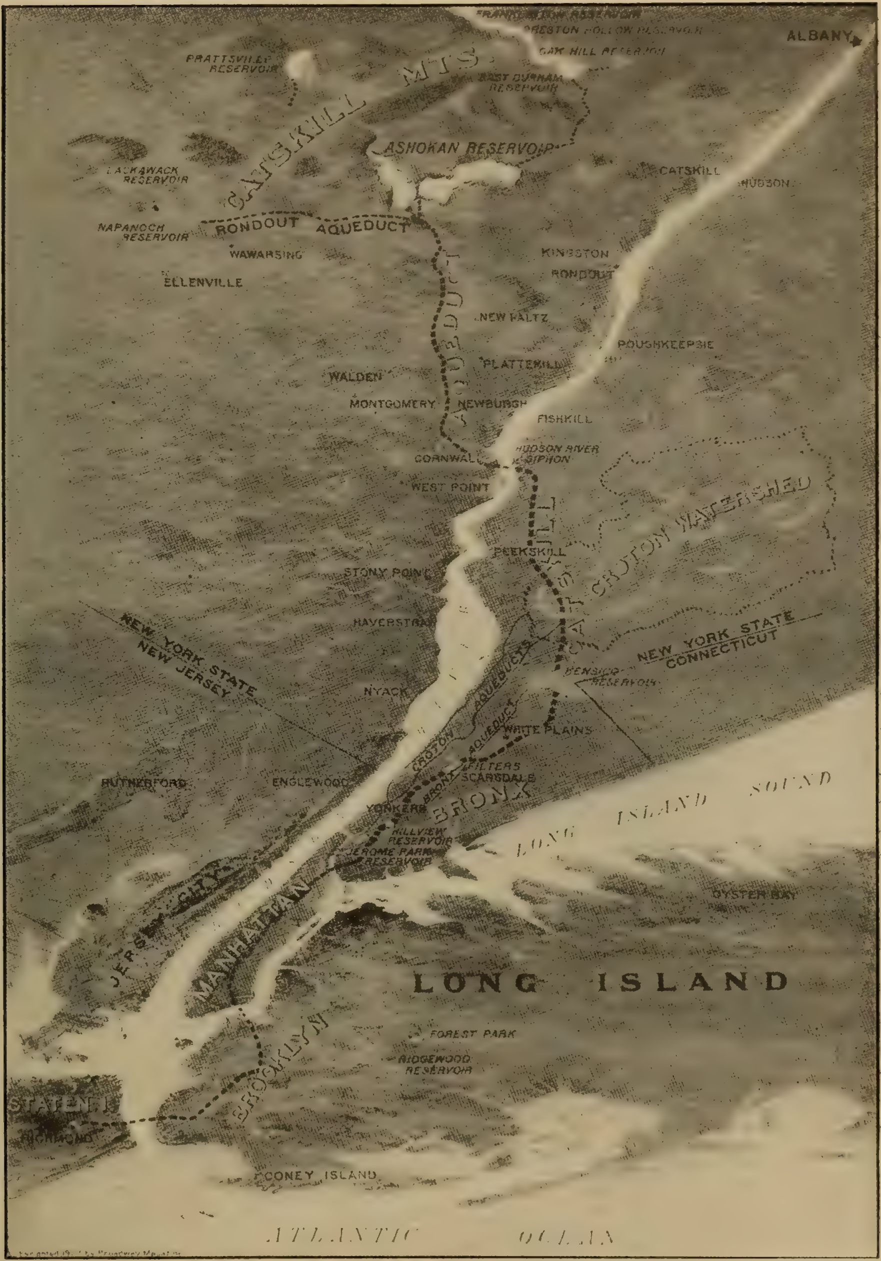
By J. F. Springer

THE city of New York covers an area of 309 square miles. This is equivalent to a rectangle 15½ by 20 miles. But the city is by no means so compact as this. From a point on the northern boundary to the opposite extremity by a southwesterly line the distance is 34½ miles. This is about as long a straight line as can be run within the municipal limits. It would cross the Bronx, Manhattan, upper New York Bay and Staten Island. The total area is divided into five boroughs. Of these, the two largest—Queens and Brooklyn—with areas of 124 and 66 square miles, respectively, are situated on the western extremity of Long Island. Richmond and Manhattan occupy islands whose areas are 57 and 22 square miles, respectively. One borough only — the Bronx—with 40 square miles, is on the mainland, but it is cut in two by the Bronx River, running south. The population of the city is concentrated mostly in Manhattan and the northern part of Brooklyn. Here reside, perhaps, seven-eighths of the 4⅞ millions of human beings. Multitudes of persons who sleep elsewhere do business in New York and mostly in the two sections of concentration noted. It will readily be understood from the foregoing that there is a wonderfully large demand for water in a comparatively restricted area. This area must be the objective point in any system of water supply having to do with the city as a whole. But such a supply must also reach the outlying sparsely settled regions as well. They may not need much water, but they do need some.

Now, great cities are seldom, if ever, built to order. They grow and spread under the influence of many and adverse interacting causes. These causes may vary from time to time, some even passing out of existence and others, absolutely new ones, coming in. In many cases of modern urban development neither the amount nor geographical direction of the growth of population can be foreseen for any considerable number of years ahead. And so it is scarcely to be wondered at, if the water system of a great metropolis should be found to have a growth apparently as haphazard as that which seems to have characterized the city itself.

In the case of New York, the difficulty of using sufficient foresight in the past will be better understood by considering a few salient facts. Three hundred years ago this second greatest city of the world did not exist. When settlements were made the city began its growth from the southern extremity of Manhattan Island. The local water supply was probably entirely adequate for a considerable period, as this island is by no means a low, flat sand pile. The high ground along the Hudson in the north must have been the location of the sources of a number of suitable streams. These, with wells and springs, must have met the demands for many years.

The development of the first beginnings into a great city has occurred during the last century. Boston and Philadelphia were both greater before the Revolution. In 1790 the population was only 33,000. In 1810 it was but 96,000. But this increase of 191 per cent. in two decades is to be taken, perhaps, as in-



Courtesy of Dr. John M. Clarke, Director New York State Museum.

CATSKILL WATERSHEDS AND ROUTE OF AQUEDUCT

dicative of what was to come. However, the next ten years added less than 30 per cent.—a considerable increase, but less than one-third of what might have been expected. Nevertheless the city went on, adding wonderfully to its population, and became the greatest city of the New World. In 1860, just before the Civil War, 800,000 people inhabited

Manhattan Island. In 1890 the city had a population of 1,500,000. It would have been difficult to have foreseen all this many years in advance. Even if some far-sighted person had grasped the full significance of all the factors at work, the rate of growth was so extraordinary that it is to be doubted whether at any time during the years between 1810 and 1890 the city could have been reasonably expected to undertake the task of fully meeting the demands of the subsequent twenty or thirty years. In 1874 some territority to the north of Manhattan Island was incorporated in New York City. But in the decade following 1890 not only other portions to the north were added, but the Long Island and Staten Island boroughs, including the large city of Brooklyn, were merged into one great municipality. There were thus included many independent or semi-independent centres of population. The water supply of Greater New York came thus to include twenty-five different systems. It would scarcely have been within the bounds of the possible to have inaugurated at any previous date a single system adequate to the supply of this new city. That old New York had been making great efforts to provide for her own probable needs for a considerable future period the Croton system is a witness. Let us look briefly at this and thus become prepared to consider the larger problem now in course of solution by the Catskill project.

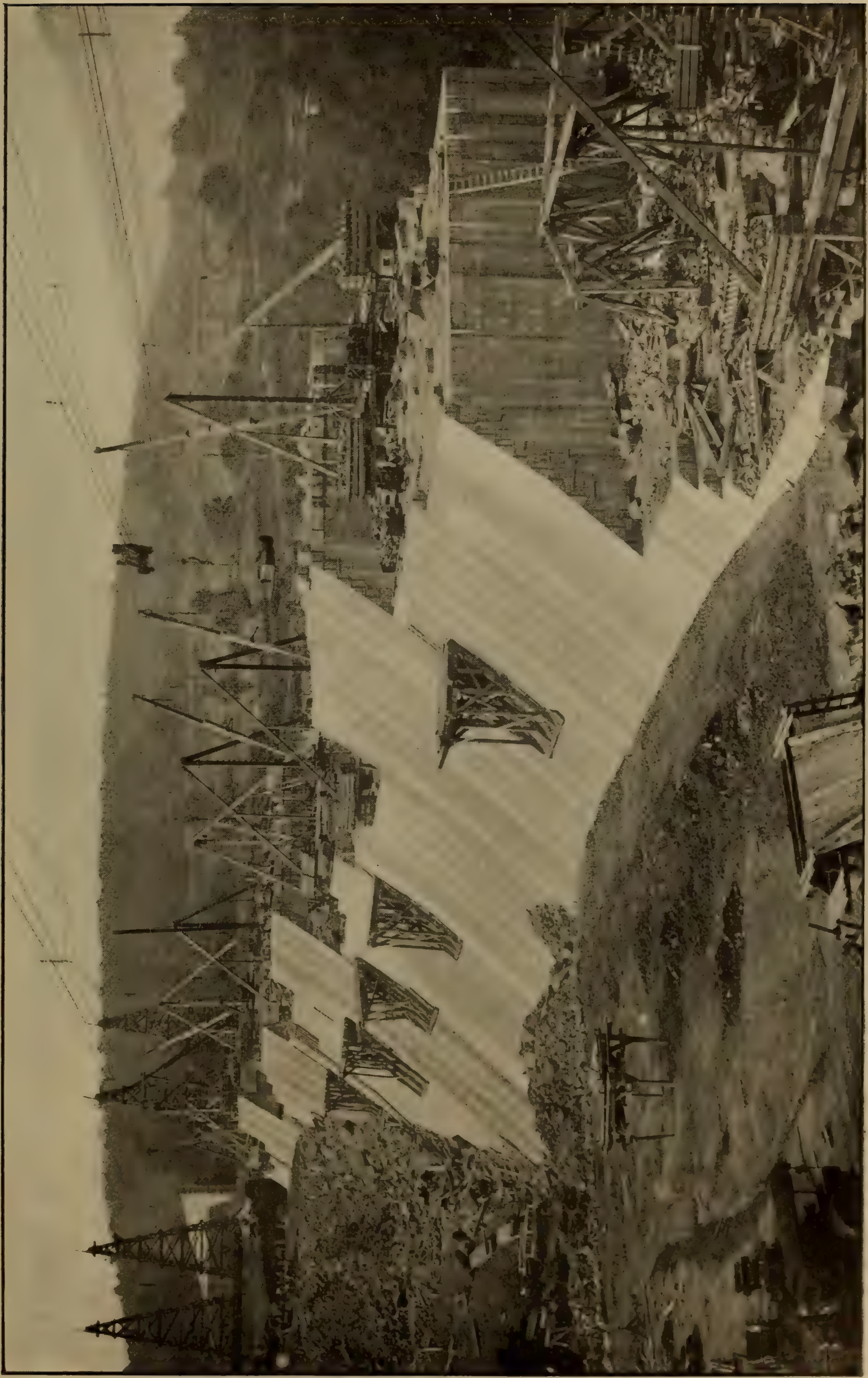
Away back in 1842, when the population was hovering around the 300,000 mark, water was conveyed by the old Croton Aqueduct. The Croton River empties into the Hudson from the east at a point about 40 miles north of the City Hall. The former river was dammed at a suitable point and the water conveyed to the city by an aqueduct 38 miles long, at a cost of about $329,000 per mile. The conduit is 8 feet 5 inches high and has a maximum breadth of 7 feet 8 inches. The fall is very gentle, being only about 13.25 inches per mile. At the Harlem River, which divides Manhattan from the mainland on the north, the aqueduct was carried over in metal pipes 150 feet above the surface of the stream. But the city was then adding to its population at the rate of about 6 per cent. a year. A new aqueduct was opened in 1890—nearly half a century later. This newer waterway is 33 miles in length, and has a flat floor and arched roof. It is 13½ feet high. To cross the Harlem River, an inverted siphon was constructed having a maximum depth of about 300 feet below the stream. At 135th street and Convent avenue this new conduit comes to the surface and its waters are distributed by a system of metal pipes. But the water supplied by the two aqueducts was inadequate to the old city's needs. This was foreseen before the completion of the new structure. It was decided to construct a new dam across the Croton about 6 miles back from the Hudson, and to divert the Croton River so as to lay bare the site. The diversion channel was a thousand feet long and 200 wide. The excavation necessary involved the removal of a million cubic yards of spoil. The dam itself is a noble structure, 296 feet high and 2,168 feet long, if we include 1,000 feet of spillway. It is 200 feet thick at the base. A driveway 20 feet wide extends across the crest. The masonry and other materials used have been estimated as having a weight of 1,200,000 tons. The available water supply in storage that is thus created amounts to 31,000,000,000 gallons. As the old storage facilities in the same watershed amounted to 43,000,000,000, it will be seen that this new dam brings the total to a great amount. The entire watershed of the Croton River is about 360 square miles, and is but thinly settled, except in a few localities. The new dam has created a lake 20 miles in length, submerging the old dam to a depth of 34 feet. To supply this lake there is an average yearly rainfall of 48 inches. But there is a large water surface of, perhaps, 19 square miles from which there is a very considerable loss by evaporation. It is said that this loss is sometimes greater than the monthly flow. Both aqueducts are fed by this lake. The areas of the respective cross-sections are about 53 and 154 square feet. The daily capacities of the two are 80,000,000 gallons and 300,000,000 gallons. As the average grades are 1.1 feet and 0.7 feet, we should have expected a less capacity from the new aqueduct than is really the case. Its capacity is actually 3.75 times that of the old, in spite of a cross-section only 2.9 times as large and a gentler grade. Moreover, the alignment of the new is, apparently, more broken than that of the old. It would seem that all these considerations are more than offset by the reduction in frictional resistance realized with the large cross-section. The surfaces of contact, assuming identical forms of cross-section, are to each other as the perimeters. These, in turn, are to each other as the square roots of the cross-sectional areas. We thus find that the ratio of surfaces of frictional contact are to each other as $\sqrt{2.9}:\sqrt{1}$. This gives 1.7:1. With this consideration before us we are prepared to understand the more than proportionate increase of capacity of large conduits. If I inquire as to the influence of the form of cross-section, I find at once that a circle includes the greatest area for a given length of perimeter. It seems, then, that when other things are equal, a circular cross-section will develop the least friction. A typical section of neither aqueduct is a circle. But that of the newer structure approximates more closely to one, so that we have here another consideration favouring its greatest relative capacity.

Courtesy of Dr. John M. Clarke, Director New York State Museum.

BEAVER KILL DIKE SITE

The pressure, due to a head of, say, 115 feet, is about 50 pounds per square inch. This is not realized until the conduits are near the Harlem River. As the new aqueduct here drops about 300 feet down, we get the very high pressure of about 180 pounds per square inch at the bottom. When the old aqueduct crosses on the masonry structure known as High Bridge it is divided into one 7-foot and two 3-foot pipes. The old Croton works are said to have cost $12,000,000. If we add on the new system, together with certain minor works, we have a total of about $100,000,000.

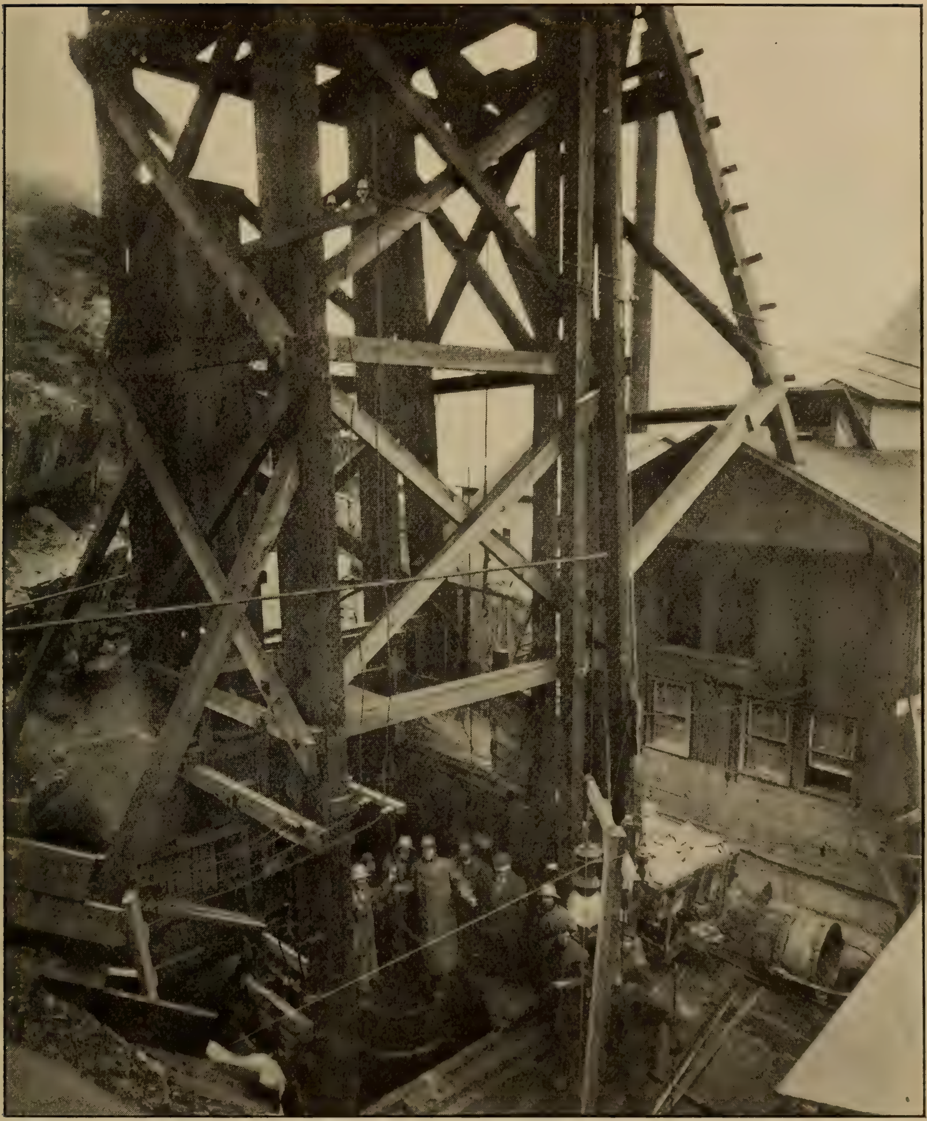
These systems bring into New York a magnificent quantity of water. But they supply only two boroughs, the Bronx and Manhattan. The Borough of Brooklyn, with its population of more than a million, receives nothing from the Croton supply. Nor has it seemed very practicable to seek to satisfy requirements by the methods adopted for Manhattan and the Bronx. This is because of the difference in the watersheds. The Croton area is supplied with strata more or less impervious. On Long Island, in the neighbourhood of Brooklyn, the soil is quite pervious. The rainfall sinks into the sand and gravel until it is absorbed by the bed of perpetual saturation, and thus finds its way eventually to the sea. The movement seaward is incredibly slow, being estimated at less than 5 yards per day. The slope of the water-table is only about 10 feet per mile. There are streams, of course. Some of these, whose beds cut into the water-table, are supplied both by surface water and by the underground flow. But there is but little opportunity to form a large reservoir and use the irregularly accumulated volume of water in a more or less regular way. However, there is the underground sheet of water equivalent to a lake, because of its gentle movement. When the seasons have completed a full cycle the water has moved less than a mile horizontally. Besides, the water has, in large part, reached the bed of saturation through layers of sand. And in the water-table sand is thoroughly mingled with it, so that we have thus a sheet of filtered water. The only problem is how to get hold of it. Brooklyn has used the surface supply, but to-day a large part of what she uses comes from below. The first effort, as we are informed by Mr. W. W. Brush, was in connection with an open brick well about 17 yards in diameter. No great amount of help was gained, however. Nearly thirty years ago clusters of 2-inch wells were sunk to a depth of about 40 feet. These were about half a mile back from salt water. A central suction pipe about 700 feet long connected with these. A hundred or more of such wells corresponded to each station. At the bottom strainers 5 to 7 feet long were employed for the purpose of separating sand and water. A typical strainer consisted of a ribbed-iron frame over which perforated sheets of brass were soldered. This system seems to have been pretty successful, for other wells were sunk of 4½ to 8 inches in diameter. The strainers were made from 10 to 20 feet long. These strainers were constructed of perforated brass sheets enveloping brass or iron frames, or they were made of solid brass. Some wells had not only strainers at the bottom, but the strainers were enveloped and underlaid with gravel. In some cases vitrified pipe was used in connection with gravel. The employment of gravel seems to have been comparatively successful. But the whole well system came into disfavour because of clogging and because of the inefficiency and expense of the small stations. Two considerable galleries were accordingly constructed. One of these consists of a well of brick 18 feet in diameter, with long arms of vitrified tile pipe extending horizontally and below the surface. The well was sunk to an elevation of —10 feet. The pipes, 36 inches in diameter at the well, taper off gradually to 20 inches at the outer ends. They extend across the line of flow of the water in the



MASONRY SECTION OF OLIVE BRIDGE DAM, SHOWING THE DOWNSTREAM FACE, LOOKING SOUTH water-table, and are surrounded with gravel. The joints are left open. The inverts of the pipes are 5 feet above the well bottom. The entire length of this gallery—the Wantagh gallery—is 2¼ miles or thereabouts. Each pipe drops 3 feet along the invert as it approaches the well. By this method a supply averaging 1,000 gallons daily per lineal foot of pipe may be obtained at an expense of $15 per lineal foot for construction. The Massapequa gallery is of the same general design, but is half again as long. Brooklyn derives her supply in part from these galleries, in part from the streams, and in part from wells.

The remaining boroughs of Richmond and Queens derive their water supply from driven wells. The Borough of Richmond (Staten Island) is to obtain some additional water from the near-by New Jersey mainland. The Croton Falls reservoir will add something to the Croton possibilities. It has been estimated that with this addition the safe minimum supply of water available for Greater New York will be 547,000,000 gallons per day. Present consumption nearly equals this amount. About 1911 or 1912 it is reasonable to expect an equality between supply and demand. It will readily be seen, then, that there is urgent need for an increase in the water available. So far as Brooklyn, Queens and Richmond are concerned, their increase for the present may be safely sought on Long Island. Delivery into Richmond would involve the use of submerged pipe lines at some point in the Narrows, as the eastern strait connecting upper and lower New York Bay is called. Provision for Manhattan and the Bronx must be made elsewhere. This problem was attacked some years ago and a supply sought on the east side of the Hudson to the north of the city. But opposition of such a character developed that, in consequence, New York is now engaged in the gigantic undertaking of bringing in an enormous supply from a new and distant section. A watershed whose central point is 100 miles distant from the City Hall and which lies on the western side of the great and navigable Hudson River has been selected. This lies in the region of the Catskill Mountains. Not only must the water be stored in one or more mighty reservoirs, not only must a great aqueduct be constructed of tremendous length, but this aqueduct must be gotten across the Hudson. The problem involved in this last requirement is quite a formidable one. Because of unexpected difficulties, it is, perhaps, greater today than when first attacked.

By an official recommendation in 1905 the Catskill project was put into tangible shape. It was estimated that the expenditure of $162,000,000 would develop four watersheds in the Catskill Mountains and construct a conduit of sufficient capacity to deliver 500,000,000 gallons daily to New York City. Included in this estimate were works of a capacity to deliver 100,000,000 gallons of the total daily supply to Queens and Brooklyn, and a connection between Brooklyn and Richmond. But this enormous sum of money was not expected to accomplish delivery to the Bronx and Manhattan. It was suggested that one-half of the total half-billion gallons per day could be secured by expending $112,000,000, and that the whole scheme could be carried to completion subsequently. This general plan is now being worked out and an advanced stage of construction reached. Four creeks in the Catskills and their watersheds constitute the source of supply. These are the Esopus, the Schoharie, the Rondout and the Catskill creeks. In the valley of the Esopus the monster reservoir is under construction. Schoharie Creek will be diverted by tunnel to empty into this lake. It is proposed to bring the waters of Rondout and Catskill Creeks by tributary aqueducts con-



EAST TEST SHAFT ON THE HUDSON RIVER DIVISION, SHOWING MEN READY TO DESCEND SHAFT

nected with the main one. The great storage lake will be known as Ashokan reservoir. The two basins will have a total superficial area of approximately 13 square miles. To drive round will be a journey of 40 miles or more. This great tank will hold about 128,000,000,000 gallons. Ashokan dam will be about 1,000 feet long on the crest and 240 feet high.

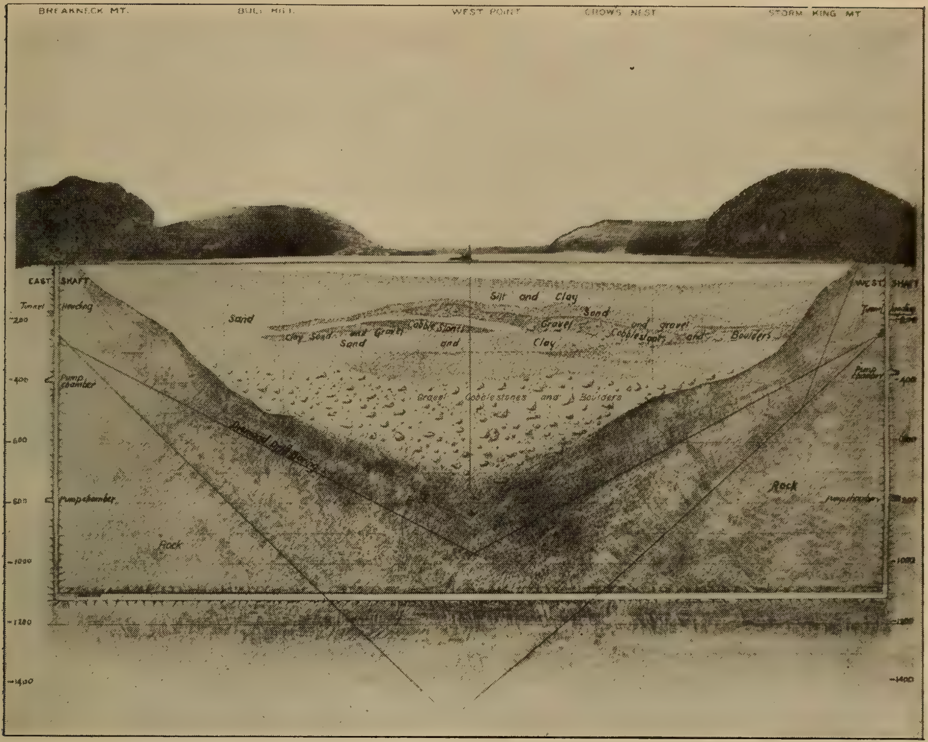
Without including Rondout and Catskill Creeks, the total watershed will have an area of 485 square miles. The lake will have an average depth of nearly 5 feet. The aqueduct will lead from Ashokan reservoir, where the hydraulic gradient is 510 feet above tide across country, down hill and up hill, below the Hudson River at Storm King, up again on the eastern side, on across country to Croton reservoir, through this to Kensico reservoir. Here the hydraulic gradient has fallen to 355 feet. After a drop of 25 or 30 feet the aqueduct will continue a few miles further to Hill View reservoir, not far distant from the boundary line of New York City. The gradient has now fallen to 295 feet. There has been a total reduction of 215 feet. The Kensico reservoir, with its capacity of 40,000,000,000 gallons, is to perform the service of a storage tank upon which the city may draw even when the long section of the aqueduct to its north is cut out of service because of accident or the need of repairs. Hill View reservoir, with a capacity of 900,000,000 gallons, will perform an equalizing duty. From this body of water the aqueduct is to run underneath the boroughs of the Bronx and Manhattan, making the passage of the Harlem River below the bottom. It is also to pass beneath the East River to the Brooklyn side at a point near the Navy Yard. Distribution is to be effected from this underground waterway. As has been pointed out, this will not be the first instance of distribution for a large population from a pressure tunnel, the Croton system having afforded a prior example. By means of pipe connections distribution will be effected throughout Manhattan and the Bronx. On the Long Island side it is not proposed to extend the pressure tunnel for any considerable distance, but to effect distribution by large pipes. The Catskill water is to be carried, however, beneath the Narrows from Brooklyn to the Borough of Richmond. It will, accordingly, have traveled a distance of, perhaps, 120 miles, have made the passage of the Hudson River, Croton Lake and the Harlem River, and have passed beneath those arms of the sea known as the East River and the Narrows. As an equalizing reservoir is to be located on Staten Island, the water will also have been in four reservoirs before final distribution in Richmond. It will, perhaps, have been 510 feet above the sea at Ashokan reservoir and 1,200 feet below the surface of the Hudson at Storm King. But it will never have been outside the State of New York. It will have come from the mountains of the continent and have been on three considerable islands.

Taken in connection with present resources, the city of New York will have, upon the entire completion of the Catskill project, a daily water supply of one billion gallons. This will be thoroughly distributed over an area of 309 square miles, thus supplying an average quantity of nearly one pint of water daily for each and every square foot of surface. If London had now, or should secure, a corresponding supply for its 693 square miles of area, the total would be about 2¼ billions of gallons daily.

The construction of the Catskill aqueduct has reference to the works at the point of origin, of the conduit through the cross-country sections, of the great inverted siphon at Storm King, of the two reservoirs on the east side of the Hudson, and, finally, of the two subterranean and subaqueous tunnels through the city and beneath the East River. The chief structure at the northern terminus is

### ASHOKAN DAM

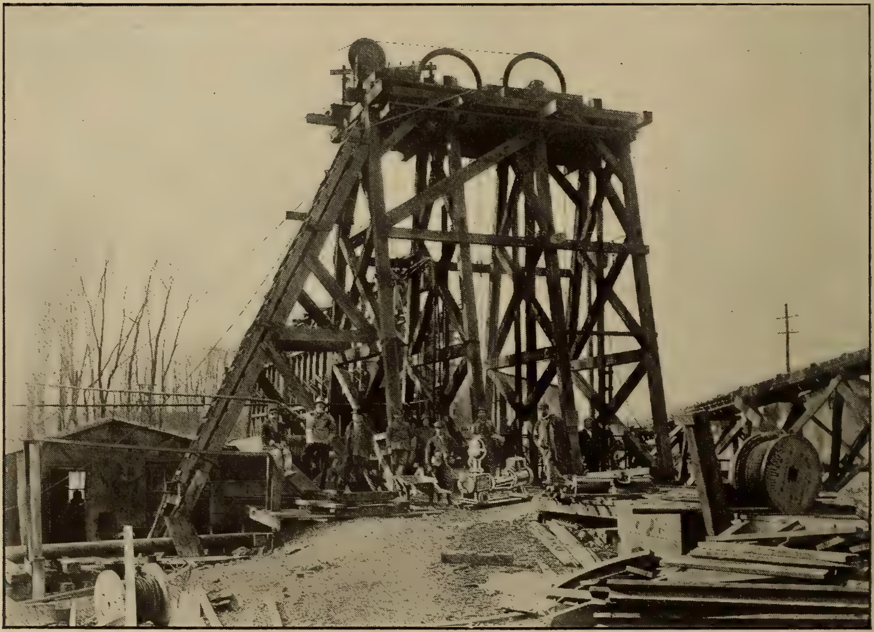
In the prosecution of many engineering operations in the old days the engineer was compelled to work with insufficient knowledge of conditions that are almost essential factors. Perhaps in no line of endeavor is this statement more conspicuously correct than that where foundation construction is involved. A dam 200 feet high will exert a pressure of 216 pounds per square inch upon the stratum that supports it, assuming the specific gravity of its materials to be 2.5. Absolutely no uncertainty should exist as to the rigidity and supporting power of the underlying material. Matter is, no doubt, incom-



SECTION OF HUDSON RIVER AT STORM KING, SHOWING BORINGS AND PRESSURE TUNNEL

pressible, so that a pocket of sand would support any weight, if itself sufficiently supported by the containing walls and bottom. What the engineer must seek is this ultimate support. This he finds, in an ideal way, in what he calls the bedrock. But the necessity of going to bedrock may sometimes be avoided. In the case of a high dam it is necessary that the strata intervening between the foot of the structure and the bedrock shall be impervious. But where is the bedrock? Is it a few feet below or many? And what is the character of the intervening material? Upon the answers to such questions as these the expenditure of great sums of money may turn. If the structure is a dam of large proportions, then the choice between alternative sites may be determined by sub-surface conditions. In fact, this very case presented itself in connection with the Ashokan dam. Two locations were proposed—the Tongore site and the Olive Bridge site. Judging from surface topography, the former was to be preferred. And the entire structure in that case would have had to be only 2 miles in length, as compared with 3.8 miles in the latter. If the dam were built on the Tongore site, two dikes of low height would have been needed. For these, suitable and economical locations were readily found. But as to the underground conditions on the site for the main dam, the greatest uncertainty existed. In the sequel $31,600 were spent on test-shafts and bore-holes to learn with exactness just what these conditions were. Three test-shafts, having a total depth of 200 feet, and 74 small holes, aggregating a depth of 8,300 feet, were put down. At the gorge of Esopus Creek the borings were, in general, satisfactory. Sandstone, shale and an impervious earth seem to have been the materials penetrated. Few or no fissures of a troublesome character were found. But on carrying the work further north the impervious stratum was found to be underlaid by water-bearing sand. Indeed, the bedrock sank to a depth 80 feet below the bottom of the rock gorge in which the Esopus now flows. This new depression filled with sand was, no doubt, the preglacial gorge of the stream, the sand having been deposited, perhaps, under an increased sluggishness of the creek induced by subsidence of the general surface. The impervious stratum—a glacial drumlin—perhaps thrust the creek southward under the impulse of the ice subsequent to the deposition of the sand. At any rate, here was a pocket or layer of sand 150 feet deep underlying the impervious material. To construct the dam on the Tongore site would have involved carrying the foot to a depth where the maximum height would have been 290 feet. The engineers became convinced of the inadvisability of attempting to permit the sand to underlie the dam, because of several considerations tending to show that it was really porous. Thus, as Mr. D. S. Mallett states, a number of the borings into the sand emitted gas. One hole, where the casing had been left in, enabled the sound of running water to be heard several weeks after completion. Ordinarily, when a bore hole reached the sand water would be lost. But a shaft sunk in this neighbourhood encountered a flow of 10 gallons per minute at 87 feet. A few feet deeper 100 gallons per minute were coming in. Indeed, a flow of 160 gallons per minute was developed later. Ultimately the shaft was given up because of the great quantity of water. To use this site would have involved the construction of a very expensive core wall. In short, the result of these investigations was to throw doubt on the advisability of building the dam here.

The Olive Bridge site involved a main dam across the Esopus at Olive Bridge and an extensive dike construction at Beaver Kill. The site



LOWERING A STEAM PUMP INTO THE HUDSON TUNNEL

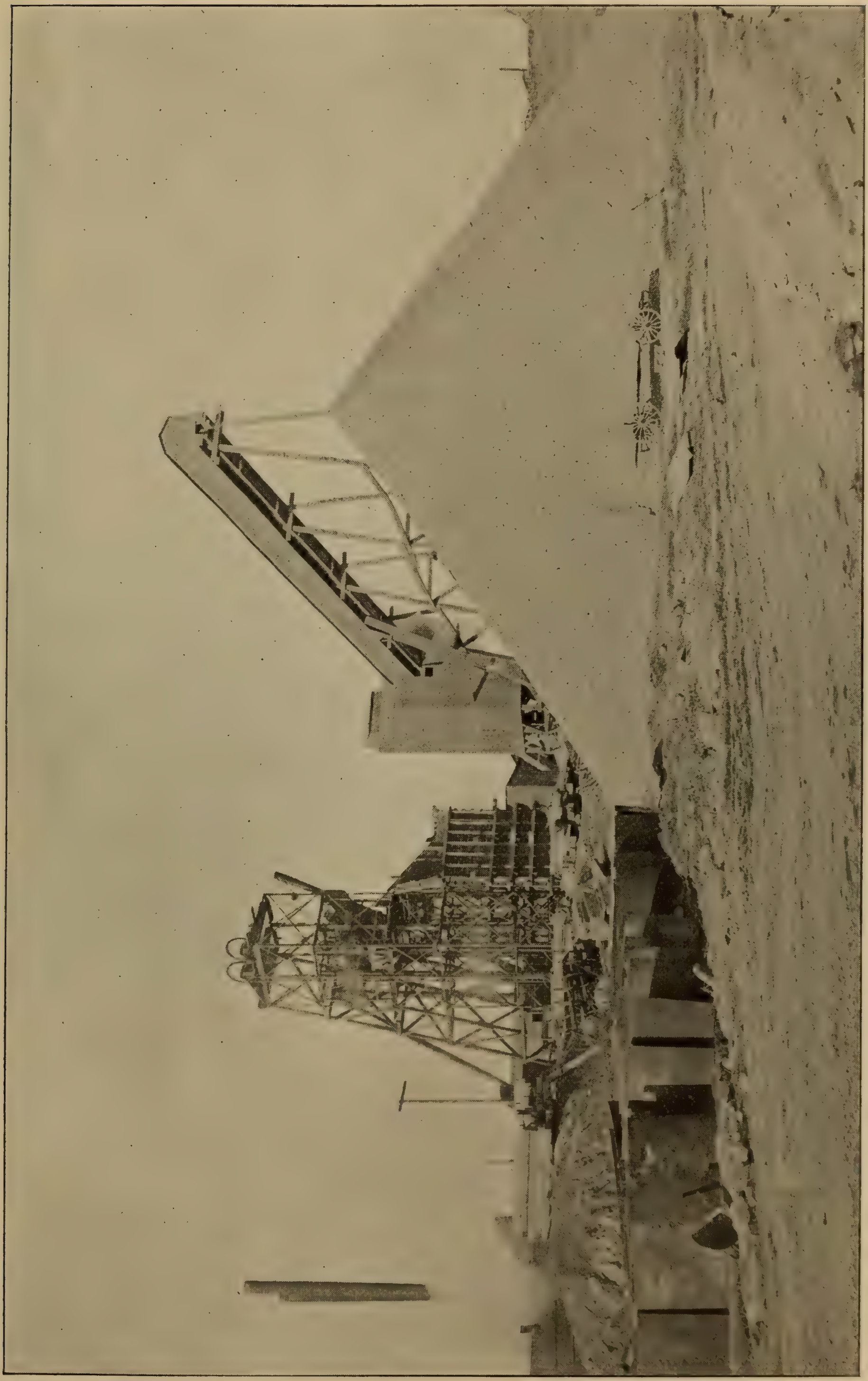
PORTAL OF THE BONTICOU TUNNEL. WALLKILL DIVISION OF THE CATSKILL AQUEDUCT

for the main dam was nearly a mile in length. To investigate it, 150 bore-holes, having an aggregate length of 11,500 feet, and a shaft of 166 feet in depth, were sunk, at an expense of $55,400. The Esopus here passes through two hills, the stream itself having its bottom in a rock gorge only about 110 feet below the desired hydraulic gradient of the reservoir. On the south bank the bedrock of the hill is covered by an earth stratum nowhere found to be more than 40 feet deep. The northern hill, however, consists of a very deep layer of earth. But this is impervious material. The borings were carried down to bedrock. As at the Tongore site, an ancient gorge of the stream was found at a lower level and further north. Here one might expect to find sand—and, perhaps, porous sand at that. But such was not the case. Deposits of this material were nowhere found on the Olive Bridge site. However, a deep shaft was sunk in the immediate vicinity of the indicated position of the old gorge and carried down to the rock, 166 feet below. There was water in various bore-holes, but apparently the levels were independent of each other. This was taken to indicate impervious material.

The result of the investigations by boring and shaft-sinking, amounting to $97,000, was the rejection of the Tongore and the acceptance of the Olive Bridge site. Conditions at the latter location permit the construction of a masonry dam over the present gorge having a height of 210 feet and flanked by earth structures to each side. On the south the core wall will go to bedrock—it is so close at hand. On the north it will penetrate the impervious material to a depth of about 20 feet. The masonry section will be about 1,000 feet long. The whole of the main dam has a length of about one mile.

There remained, however, the investigation of the Beaver Kill dikes, and the results here were probably taken into account in making the final decision for the Olive Bridge site as a whole. The necessary dikes aggregate a total length of nearly 3 miles. The centre line for the main structure extends northeast from the hill into which the northeast end of the main dam extends. It then makes an angle of, perhaps, 135 degrees, and continues eastward to another hill. Beyond, there is an extension to the southeast. We thus have the principal line of the dikes. The investigation of the site for the dikes involved the expenditure of $24,000 for 5,500 lineal feet of bore-holes and 73 feet of depth for shaft. There were a couple of exceptions, but the site, as a whole, was found to disclose an impervious layer of earth 30 feet thick, underlaid by rock of good quality. However, on the west end, where the line runs northeast and southwest and near the hill already mentioned, it was necessary to go down 250 feet before reaching bedrock. Apparently, here was a pre-glacial gorge, but whether it had been the ancient bed of the Esopus or not was not learned. The lowest point reached was about 50 feet lower than the old bed of the Esopus at a point about half a mile away. By displacing parallel to itself the centre line of this section of the dikes, the gorge was avoided. The core wall is here to rest upon bedrock. Where the east-and-west section—perhaps a mile and a half long—crosses the present location of Beaver Kill, a pre-glacial gorge, 80 feet below the bed of the present stream, was found. This was 150 feet in width and found to contain water-bearing material. In seeking to learn how porous this material was, large quantities of water were artificially supplied to the bore-holes, with the result that in some cases it ran away as rapidly as supplied. In view of conditions as disclosed, a core wall extending to bedrock was provided for in the design. Elsewhere the core wall was to extend about 20 feet into the earth, but might reach 40 feet where necessary.

It will be gathered from what has already been said with regard to certain pre-glacial gorges that the sub-surface conditions in the Catskills must be very uncertain. This is true, but the uncertainty extends much further. In very ancient times from an historical viewpoint, but in very recent ones geologically speaking, great sheets of ice hundreds, perhaps thousands, of feet thick invaded the northern part of the United States from the highlands of Canada. This monster glacier, just as the more modern examples of to-day, thrust soil and rock ahead of it, ground the material beneath it, and carried within it and on its surface other material accumulated during its slow but long-continued forward movement. It is not difficult to see that surface conditions would be much changed. First, the grinding and scraping and shoving would change the soft-soil surface markedly, and the rocky surface to a less extent. Streams would have their location altered. Hills would be swept away and blocks of rock carried off. Second, the abandonment of its rock and earth contents when at last the ice melted under the influence of climatic changes would produce new deposits of material. Third, the water from the melting ice would occasion great floods, resulting in modifications of the surface changes which would otherwise have taken place. There were, probably, several ice invasions. The State of New York, amongst other northern regions in the United States, was much affected by glacial action. Prior to the activity of the ice—or prior, at least, to the most recent activity—the Atlantic Coast in the region of New York had been undergoing an elevation of its general surface from the operation of geologic causes. In consequence, many streams cut deep gorges in the solid rock in the process of seeking their level. There was subsequent subsidence of the general surface. This would have the effect, where the interior went down faster than the region near the coast, of making the streams more sluggish and thus increasing the deposition of sand and



HEADWORKS AND STONE-CRUSHING PLANT AT THE DOWNTAKE SHAFT ON HILL VIEW DIVISION gravel back from the shore of the sea. It was, perhaps, due to just such causes that the deposit of sand in the old bed of the Esopus at the Tongore site occurred. The intermingling of pre-glacial and glacial effects has operated to render very uncertain all engineering judgment of sub-surface conditions, both in New York and other affected regions.

The construction of Ashokan reservoir constitutes one of the large items involved in the Catskill project. This reservoir is to gather the waters from a territory of 140 square miles extent. The water level is to be at elevation +590. The amount of excavation involved is about 2,500,000 cubic yards, of which nearly 20 per cent. is in the rock. The construction of the great dam and the several dikes involves over 8,000,000 cubic yards of material. The concrete masonry alone amounts to about 880,000 cubic yards.

The three dikes are to be of earthen construction, a concrete core wall being used to prevent the undermining of the embankment. Altogether, they have a length of about 20,000 feet. The Olive Bridge dam, with its two wings, adds about 4,800 feet additional. These structures taken together form a flat or obtuse V, with the vertex to the north. At this vertex a weir, extending north, divides the reservoir into two basins. Altogether, there is a total length of dam considerably in excess of 25,000 feet. The aqueduct itself is to extend southward from within the vertex, and thus constitutes a kind of extension of the dividing weir. The main line of the Ulster & Delaware Railroad cuts across the V just south of the vertex and thus intersects the sites of the east and middle dikes. The vicinity of the railway has been of great service to the contractors, as it enabled them to bring equipment, cement and the like to the spot. They constructed a branch, which facilitates transportation in the neighbourhood.

The most interesting piece of construction is the Olive Bridge dam. The central structure extends across the gorge of Esopus Creek. This gorge is about 40 feet deep and perhaps 200 wide. The Esopus varies from quite a small stream in dry weather to a torrent delivering 38,000 cubic feet of water per second. The site was freed from interference by the construction of up-stream and down-stream cofferdams. The water was conducted through the intervening space of about 360 feet by the use of two 8-foot steel pipes. As the combined sectional area only amounted to about 100 square feet, these pipes would have been entirely inadequate for anything approaching flood conditions. But they served a temporary purpose, permitting concrete construction to be brought to their level. The dam is faced upstream and down with concrete blocks enclosing a cyclopean fill. The blocks are made in wooden moulds having steel linings. It is thus possible to secure a smooth surface in the finished block. The concrete is a 1:3:6 mixture. The sand is obtained from a pit about ¾ mile away, and is of fine quality, clean and sharp. It has been found necessary to screen but little. The stone is secured from a quarry some 3 miles away and brought upon a standard-gauge railway to the spot. Previous to transportation the rock is crushed to size. In the manufacture of the blocks, which are sometimes 7 feet in length, the moulds suffer sometimes a slight distortion, which is corrected by the use of a horizontal diagonal rod joining two of the corner posts. By the use of adjustable tie-rods it has been found possible to secure great accuracy in the construction of the blocks. After being cast the blocks are allowed to mature three months or more.

At its base the dam is 190 feet thick. It tapers to, perhaps, 25 feet just below the crest. From bedrock to the water level when the reservoir is full is about 190 feet, so that there is a down-stream thrust of about 82 pounds per square inch, or nearly 12,000 pounds per square foot. The up-stream face is nearly vertical, and the down-stream one begins very steep at the top and becomes more gentle towards the bottom.

There are a number of vertical expansion joints. There are rectangular recesses arranged here. One face is built of blocks and the other of mass concrete. Before pouring the latter the blocks have their faces thoroughly greased, to prevent adhesion of the concrete. When the concrete is poured, care is taken to have a dense surface of contact. The purpose of these joints is to localize the effects of expansion and contraction strains.

SHAFT ON THE MOODNA SIPHON OF THE HUDSON RIVER DIVISION, CATSKILL AQUEDUCT.

The construction of the great conduit from Ashokan reservoir to New York City is not the simple problem of building a half-buried pipe line across the country. Such a procedure is, indeed, possible through a great part of the districts traversed. Thus, as we are told by Mr. Robert Ridgway, such a method is to be pursued through 60 per cent. of the line from the dam at the origin to the watershed of the Croton River. The remaining 40 per cent. will be below the general surface. Eleven per cent. will be at aqueduct grade, but through hills and the like. The remaining 29 per cent. will be siphon construction below grade, but not necessarily below surface. However, the part that is below surface, taken in connection with the tunnel portions at grade, amounts to 13.5 miles, or 22½ per cent., of this portion of the aqueduct. It will thus be seen that we have here the necessity for a sub-surface investigation along the line. For perhaps 30 miles after the aqueduct leaves the Ashokan reservoir its line parallels the Hudson River. In consequence, the watersheds tributary to this stream are cut across. To pass from valley to valley means tunneling. To pass across the valley may mean tunneling in carrying out the siphon construction. When the Hudson River itself is reached a very formidable sub-surface problem arises, necessitating accurate knowledge of the strata to considerable depths. On the east side of the Hudson valleys must be crossed as the aqueduct pursues its way to the Croton watershed. But in none of these cases on the east side of the great river is it expected to pass the valley by a tunnel siphon.

Two small valleys have to be passed by the aqueduct soon after it leaves Ashokan reservoir. It is purposed to use steel pipe in these valleys. The Rondout valley comes next. It will involve nearly 4½ miles of conduit to accomplish its passage. The depth below the hydraulic grade here is 300 feet, involving a maximum hydrostatic pressure of 130 pounds per square inch. It would be possible to use steel pipe 1 inch thick. But such construction, while only moderately expensive in first cost, would scarcely be economical in the long run, because of rapid deterioration. It is proposed, therefore, to make the passage by the use of a tunnel passing through the underlying rock. The necessity of burying such a tunnel deep in the solid rock in itself accentuates the problem, as thus the hydrostatic pressure is increased. The "bend" of the siphon here will probably be 470 feet or more below the hydraulic grade, thus involving a maximum pressure of 200 pounds or more per square inch. The present creek flows along near the axial line of the valley at the point of crossing. Two deep gorges are hidden below the surface to the westward. Apart from information furnished by borings, it would seem doubtful whether either of these would have been suspected from the ordinarily available geological data. And yet these depressions affect seriously the depth of the siphon. It seems that borings had previously disclosed that a deeply-buried gorge existed 8 miles to the northeast. At that point the bottom of the gorge had been found to be 70 feet below the sea-level. If it were that deep here, then it would lie about 550 feet below the hydraulic grade. The investigators were on the alert, and, sure enough, at Pinebush, on the west side of the valley, the ancient stream bed was located, with its bottom about 100 feet above sea-level, or about 380 feet below grade. The gorge was filled with glacial débris. A fault was found here showing a vertical displacement of about 130 feet. The bottom line of the siphon has been placed on this west side of the Rondout valley at a level such that the invert of the tunnel will lie about 200 feet below the pre-glacial gorge and have below it a bed of Onondaga limestone, which was one of the strata affected by the fault. Towards the east, however, and near to the present creek, the other gorge lies, perhaps, a hundred feet deeper, so that here the siphon is depressed, perhaps, 140 or 150 feet more. The ancient depression, which was probably occupied then by Rondout Creek, is filled with softer material, and would have escaped any ordinary survey. The pressures along the bottom of the siphon vary from about 260 to about 325 pounds per square inch. It is very necessary, then, for these tunnels that the surrounding rock shall not be porous and shall have support from above. Any weakness above may prove disastrous. Where the siphon bottom passes beneath the ancient Rondout gorge the excessive depression to a point about 750 feet below grade was made largely because of the desire to avoid an excessive amount of excavation through a rock known as Shawangunk grit. This material is exceedingly hard and full of seams. Bore-holes somewhat to the west of the old gorge disclosed that the strata were faulted to the vertical amount of 220 feet in a horizontal distance of 650 feet. There is also a great fold to the eastward. Running the tunnel along at a level of about 750 feet below grade enables much of it to traverse a more easily excavated rock. In coming up to grade on the eastern side it is important to know just where to make the rise. The bore-holes disclosed two faults on the east

GENERAL VIEW OF SURFACE AT THE TONGORE DAM SITE

side of the valley. The one, in the neighbourhood of Coxing Kill, occasions a local increase in the thickness of the stratum of grit. So this suggests keeping the tunnel depressed at this point. Somewhat farther to the east a great overthrust fault was found, where the soft and easily excavated Hudson River shale, which had all along been underlying the grit, overhung it. Here there was an opportunity for the eastern vertical shaft of the siphon to be located. It will be seen from the foregoing that the system of exploring by drilling is not only important, but may become wellnigh vital. It should be borne in mind that all, or nearly all, of these factors which have played so large a part in the plan were discovered where they would have remained unobserved because of overlying deposits. On the east side the tunnel passes off further eastward at grade. Here it has a ridge of the Shawangunk Mountains above it—Bonticou Crag.

The valley of the Walkill River is the next watershed through which the aqueduct passes. This is of about the same width as the Rondout valley. The conduit enters from the Shawangunk Mountains and passes by rock siphon, reaching to a depth of about 85 feet below sea-level, to the other side of the watershed. The ancient, but now buried, rock gorge has its lowest point here at an elevation of 67 feet above the sea, so that about 150 feet of rock will cover the siphon. But this advantageous crossing was not at once discovered. Thus an earlier investigation, 8 miles to the north, made it clear that there was a wide gorge whose bottom was 80 feet below the sea. The advantage of the location selected is one of 147 feet, to judge from the bottom levels. It was by persistent boring investigations southward that the depression in the rock was found to be narrower and less deep. If one considers the profile as disclosed by the drilling, he will readily see that the present depression occupied by the Walkill is quite insignificant in comparison with the ancient one, and that the present surface conditions are thoroughly unreliable as indications of those underground.

At Washington square the depression is a small one. Here it is proposed to employ steel pipe.

But the watershed of Moodna Creek, near Cornwall, is both wide and deep. The present depression occupied by the stream has its bottom about 120 feet above sea-level.

The hydraulic grade is here 400 feet above. There would thus be the considerable pressure of 121 pounds per square inch for a siphon at this depth. It has been thought best to go much deeper yet and use the rock tunnel construction here, as well as at the Rondout and Walkill valleys. The Moodna lies in a bed of soft material. A deep gorge was suspected on the north, because of disclosures in connection with a deep well and because of other geologic considerations. But what was wanted was exact information, and this the bore-holes supplied. There was, indeed, a deep gorge—two of them—with a sharp ridge between. The lowest point was, perhaps, 80 feet below sea-level, or 200 feet below the bottom of the present creek. The Hudson River gorge, near by, was known to be very deep, so that it seemed quite possible that the Moodna may in ancient times have cut its way to about the same level. For this reason it was necessary to explore the crossing very thoroughly lest a narrow canyon be overlooked. With the individual holes at intervals of 150 or 200 feet, this possible gorge was not found. And yet the Hudson canyon is 550 feet deeper than that of the ancient Moodna Creek, although at points but 2 miles apart. The presence of two gorges of considerable depth on the south-eastern part of the aqueduct line was disclosed by borings. While not so deep as the old gorge of the Moodna, they prohibit bringing up the tunnel until a position beyond them is reached. And such position is not reached until the tunnel gets to Storm King Mountain, itself on the bank of the Hudson.

But the great crossing of the aqueduct is at the Hudson River itself. As Mr. Ridgway remarks, there are a number of ways of carrying the conduit across. Thus, a high bridge, 150 feet above the river surface, might be constructed. Or it might be divided into a number of metal pipes laid in trenches in the bottom of the stream. Then tunnels could be constructed here with shield and compressed air, as has been done at New York City in driving the railway tubes beneath the East River and the Hudson. The maximum depth of such tunnels is limited by human endurance of compressed air, and is about 100 feet below the river

ATLANTIC STEAM SHOVEL, BUILT BY AMERICAN LOCOMOTIVE COMPANY FOR MACARTHUR BROS. COMPANY, AT WORK AT BROWN'S STATION.

ATLANTIC STEAM SHOVEL ON ASHOKAN DAM CONSTRUCTION. AMERICAN LOCOMOTIVE COMPANY

surface. Or a rock siphon could be constructed. The bridge arrangement would be expensive, both as to first cost and maintenance. The rock tunnel is a promising solution, but necessitates a thick covering of sound rock. The question is, Where is such rock beneath the Hudson? There can be no doubt but that the modern drilling outfit is competent to answer it, but it is no child's game. The gorge of the Hudson has, so it would seem, never been explored. Some borings in the neighbourhood of New York City had disclosed practically all that was known prior to the investigations for the Catskill aqueduct. The piers of the bridge at Poughkeepsie rest, not on rock, but on earth, 120 feet below tide level. It was expected, early in the consideration of the matter, that the siphon would have to go down deep. The hydraulic grade is here 400 feet above the surface of the stream, so that considerable depths mean heavy pressures. At the river surface the hydrostatic pressure is 173 pounds, or thereabouts, to the square inch. When we go 1,200 feet lower, in accordance with the present plan, the pressure rises to the enormous one of 693 pounds per square inch. It will be understood that no uncertainty must rest as to the character of the material. And this is the reason for going down 1,200 feet. The problem itself becomes a harder one the lower down we go. But there is so much advantage in the rock siphon that extraordinary efforts have been made to avoid giving it up. Fourteen routes have been investigated by means of the wash drill. This mode of drilling is much less expensive than with the diamond drill, and it is also more rapid. But it is inapplicable to hard rock, so that by its means one cannot tell certainly whether bedrock has been reached. The rock which stops the drill may be only a boulder. The diamond drill or its equivalent has been employed, however, at three proposed crossings. A line of bore-holes was put down at Pegg's Point, 3 miles above New Hamburg, another at Storm King Mountain, and a third at Little Stony Point, something over a mile below Storm King. At the first crossing bedrock was reached at very moderate depths—92, 241 and 165 feet. However, it is probable that the deepest level was not discovered, as operations were discontinued in favour of other proposed crossings. The investigations at Little Stony Point were not carried to rock. In fact, attention has been largely devoted to the Storm King route. Drilling is accomplished with some difficulty in the Hudson River, partly because of the passage of river craft in summer and partly because of the ice in winter. Thus, one hole at Storm King, 800 feet out from the shore, came to rock — of some kind—at a depth of 608.6 feet. It required, with the stoppage for winter, nearly a year to reach this depth and get the casing in so that the diamond drill could proceed. A penetration of 9 feet had been accomplished when a disabled steamer drifted one night against the casing, bending it below the river bottom. It was impossible to straighten it, and the hole had to be abandoned. It is thought, however, that the rock from which 9 feet of core had been obtained was really the permanent ledge, as the sample agreed with local rock. Difficulty in drilling is occasioned in connection with the explosion of the dynamite used at depths. The pressure and low temperature of the water are given as reasons for the failure to explode. Storms also interfere, and a number of holes have been lost because of the dragging of anchors.

On the east side of the Hudson the aqueduct route traverses a number of watersheds. One of the smallest is the valley of Sprout Brook, one-half mile wide and having the bed of the little stream about 240 feet below the hydraulic grade. On either side granite shows on the surface. A considerable deposit of glacial "drift" masks intervening conditions. However, limestone appears above and below the proposed crossing, so that it was necessary to ascertain the character of the rock underlying the drift. By boring, it was learned that the glacial deposit extended to a depth of 150 feet. This canyon was in limestone, a very objectionable rock in the construction of pressure tunnels. Because of the possibilities of unsoundness in the limestone, it was concluded that the siphon would here have to be carried down to a depth of 600 feet. In consequence, steel pipes have been preferred. Another case of a small valley—but back along the line—where the bore-hole decided the question was that of Foundry Brook. The results of boring were doubtful at one end of the siphon location, for the reason that the rock cores showed disintegrated rock. It was possible that the cores came from thin vertical seams, which would not condemn the whole area. In order to settle the point, a diamond-drill hole was put down at an angle. This made it clear that the rock was bad throughout. While it seemed not impossible to construct a siphon in the rock, still the steel pipe was decided upon.

(To be continued.)

# THE GREAT FALLS HYDRAULIC POWER PLANT

## THE DEVELOPMENT OF WATER POWER AT THE HEAD WATERS OF THE MISSOURI RIVER

**By M. Hebgen**

### INTRODUCTION

FROM the tower of the courthouse in the city of Great Falls the spot can be seen, hardly three miles away, where in 1805 the intrepid members of the Lewis and Clark Expedition celebrated the Fourth of July. In the journal of that famous tramp it is recited that game was not then abundant, and the quaint record is: "We contrived, however, to spread not a very sumptuous but a comfortable table in honour of the day, and in the evening * * * as is usual among the men in all festivals, the fiddle was produced and the dance began, which lasted till nine o'clock, when it was interrupted by a heavy shower of rain."

On their way up the Missouri the explorers had heard from the Indians about the great falls. They were eager to reach the scene. The story of what happened, as a part of their experience for June 13, says that Captain Lewis "had gone about two miles when his ears were saluted with the agreeable sound of a fall of water." Toward the place whence the sound came he directed his steps, and the noise increasing as he approached soon became too tremendous to be mistaken for anything but the great falls of the Missouri.

During this sojourn and, a year later, when the expedition was on its return from the coast, Captain Lewis made a careful study of this water-power and its environs. This he did with a far-distant future in view; if he did not realize what the century dating from his activities was to achieve in the way of our country's development, he apprehended, at least, the inestimable value of the industrial energy concerning which he and his companions were soon to inform the civilized world. The carefully treasured report then prepared, with its maps and charts, attest the extreme care with which he observed every aspect of the region, and is made the more interesting by the fact that the surveys of recent times establish the surprising accuracy of the data Captain Lewis set down for all the distance from the point where the waters take their first plunge to the place, miles below, where the river resumes its placid course.

Those whom local colouring interests, in connection with scenic wonders, are gratified to know that even with respect to a good many minor items the imprint of the old expedition has not been disturbed. When they were trudging across Dakota and Eastern Montana the explorers were told by Indians that at one of the falls an eagle's nest would attract their notice. They found it. The journal says: "Just below these falls is a little island in the middle of the river, well covered with timber. Here on a cottonwood tree an eagle had fixed its nest and seemed the undisputed mistress of a spot to contest whose dominion neither man nor beast would venture across the gulfs that surrounded it." They christened this cataract Black Eagle Falls; they gave the name of Coulter—one of their comrades—to another falls; they applied the stream's course to the naming of Crooked Falls; the Rainbow Falls recall the lines in which the journal speaks of

OLD TREE NEAR BIG FALLS, MENTIONED IN LEWIS & CLARK JOURNALS

"the masses of white foam upon which the sun impresses the brightest colours of the rainbow."

At a distance of three hours by railway from the city of Great Falls the Missouri River gets its start from the mingling, at Three Forks, of the waters of the Gallatin, the Jefferson and the Madison. Near Great Falls, in traversing a distance of eight miles the river's drop is 400 feet. It makes the descent over a series of cataracts, with intervening rapids, in a volume of water so great that when translated into an economic force it means more than 130,000 horse-power. Majestic power this; exhaustless in resource, limitless, almost, in its possibilities! Unknown till Lewis and Clark told about it. During uncounted centuries it ran on and on, the waste of stupendous energies. Indeed, for decades after the finding of it by the men who explored this region it was a useless treasure.

The time is within the memory of men now at manhood's prime when Great Falls power was first applied to industries in Montana—an insignificant draft was made then upon the available total. In fact, the present day is witnessing the first efforts, under Mr. John D. Ryan's discerning guidance, to adapt this splendid force to a fair measure of its ability and its opportunities. In this progressive commonwealth there is need for every drop of this water converted into an industrial agency. For the uses of the mammoth copper-making plant at Anaconda 5,000 horse-power is under constant transmission over a distance of 152 miles. The quota furnished to mines in the Amalgamated and Anaconda group is 15,000 horse-power, conveyed 130 miles.

These paragraphs are the preface to pages that tell of the power at Great Falls; of the dams and stations and equipment; of convenient sites for industrial plants; of transmission lines; of present service and available field; of the aggregate of power compared with that of other famous cascades; of the millions spent and spending; of relative economy in generating electricity; of the enormous conservation involved in the displacing of coal; of the economies assured and the commercial opportunities afforded.

### POWER DEVELOPMENT AT GREAT FALLS, MONTANA

The completion of the Rainbow Falls Power Development with a plant capacity of 36,000 horse-power marks the first step in the development of power on a large scale from the Missouri River at Great Falls, Montana.

As has been said, the river in this locality falls 400 feet in a distance of 8 miles, making possible a total development of 76,000 electrical horse-power continuously at the lowest stages of the river. With an amount of storage easily obtainable, by means of low dams, power can be developed much in excess of 130,000 horse-power. The total drop is divided up into a series of precipitous falls, making the development of power by a series of plants exceptionally easy.

### DESCRIPTION OF DEVELOPMENTS

The first abrupt falls are located about two miles from the centre of

RAINBOW FALLS OF THE MISSOURI RIVER

the city of Great Falls, and are called Black Eagle Falls. By means of a low crib dam, built in 1890, on the crest of the falls the available head is increased to 45 feet, and 10,000 horse-power is developed. About 8,000 horse-power is used by the Boston & Montana Smelter, located on the north side of the river, and the remainder is taken by the Great Falls Electric Properties' power station and the Royal Milling Company's flour mill on the south side. With the exception of that taken by the Great Falls Electric Properties' plant, none of this power is transmitted electrically, but is used directly at the falls and is transmitted by shaft or rope drive.

Three and one-half miles below Black Eagle Falls are located, in close proximity to each other, Coulter's, Rainbow and Crooked Falls, having a combined natural fall of 80 feet. The largest of these is Rainbow, and from it the development at this point takes its name. The head made available by these falls is increased to 105 feet by a rock-filled crib dam 29 feet high.

Below Rainbow Falls the river drops at a fairly uniform rate a distance of 140 feet in four and a half miles and then plunges down vertically 77 feet, forming the Great Falls of the Missouri River. This is the greatest fall the Missouri encounters in its entire length, and will be the site of the next power development.

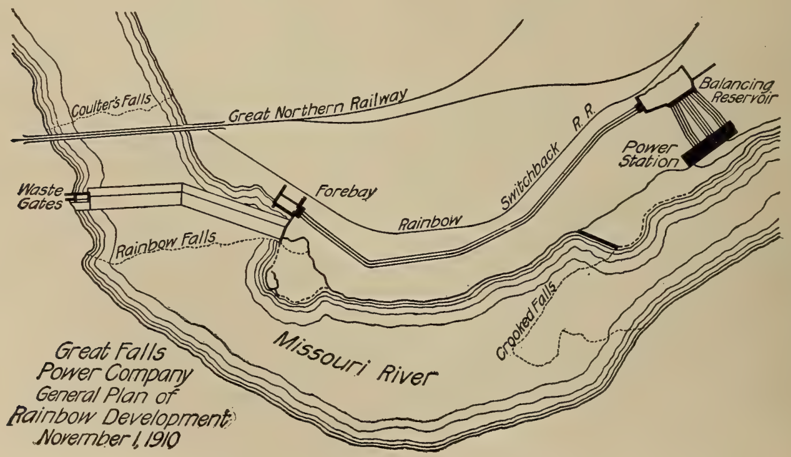
No excavation was required for the dam at Rainbow, as solid bed rock was already exposed across the entire site. The same solid rock foundation exists at the Big Falls, as well as the intermediate falls between Rainbow and Big Falls, thus furnishing an unusually good foundation for both dams and power houses at the very lowest cost.

### FLOW OF THE RIVER

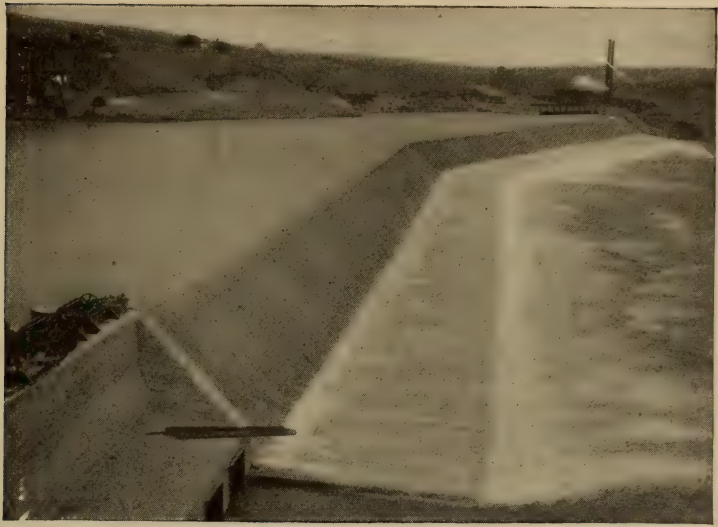
The preceding figures of available power are based on a minimum flow of the river of 2,300 cubic feet per second. Only a very few times during the last five years has the flow been less than the assumed minimum, and then for only a short time. With the amount of storage available these short low-water periods can easily be bridged over, so that the true working minimum with the plant in operation will probably be nearer 2,500 cubic feet per second than 2,300.

### RAINBOW DEVELOPMENT

The development at Rainbow was started October, 1908, and completed July, 1910. It has a total capacity of 21,000 kilowatts in generators and 36,000 horse-power in waterwheels,



MAP OF POWER DEVELOPMENT, RAINBOW FALLS



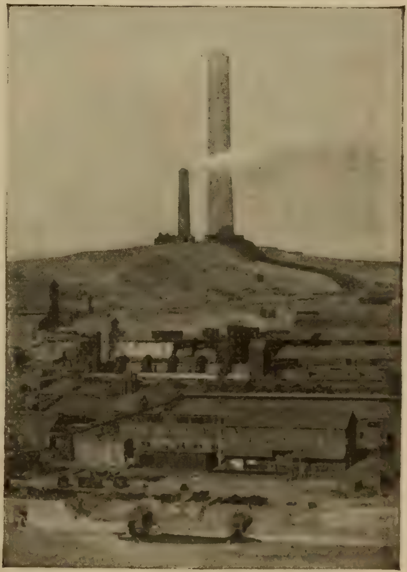
RAINBOW FALLS DAM; SLUICE GATES IN FOREGROUND

and operates at 105 foot head. The general scheme of development is typical of what may be called standard practice in the West for plants of medium head, and consists of a low diverting dam, a double pipe line feeding into a balancing reservoir near the plant, and individual penstocks supplying the turbines from this reservoir.

The dam is a rock-filled crib structure 1,146 feet long and 29 feet high, the upstream side of which slopes at such an angle that the stability of the dam is assured even under the greatest floods, the weight of the water acting to hold it down, so that the higher the flood the greater the stability. The downstream side is also sloping and tapers off into a long apron so designed as to take care of any overflow which may occur without shock or commotion. The dam is founded on solid rock throughout its entire length.

At the south end of the dam is a sluiceway having a discharge capacity of 8,000 feet per second, and controlled by hand-operated gates. Located at the north end is the intake to the pipes supplying the plant. This consists of a concrete chamber or forebay into which the water is admitted by eight openings, 8 feet in diameter, controlled by hand-operated gates and provided with screens for the exclusion of trash.

The two main pipes are of riveted steel construction, 15 feet 6 inches in diameter and 2,350 feet long. These are the second largest steel pipes in the country; a realizing



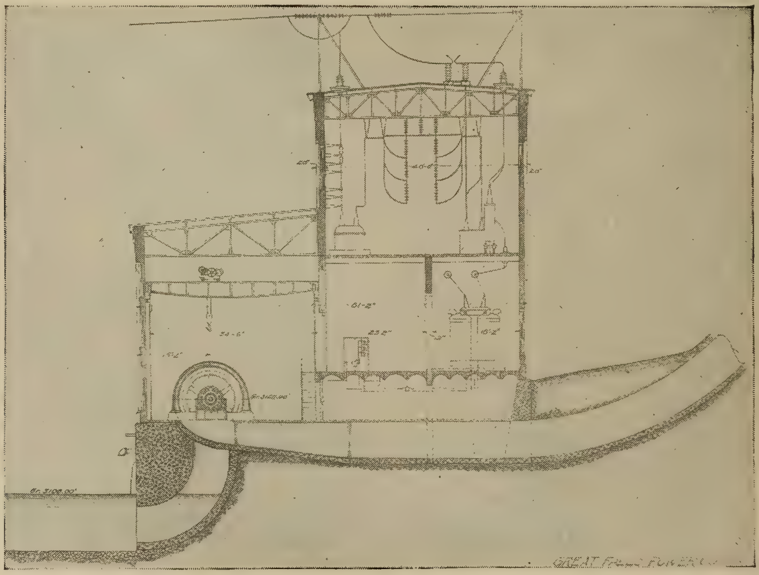
BOSTON AND MONTANA SMELTER AT GREAT FALLS. SHOWING 500-FOOT STACK—THE HIGHEST STACK IN THE WORLD sense of their size may be obtained by comparison with some familiar object; for example, they are large enough to readily allow a standard railway passenger coach to pass through from end to end. The amount of steel used in their construction was 2,471 tons, or 62 carloads, and 436,000 rivets were employed, while the steel plates, if laid flat, would cover five acres of ground.

Both the inlet and outlet ends of the pipes are enlarged to form bell mouths, thus making the changes in the velocity of the water gradual and minimizing the loss of head. Stop log guides are provided at each end, so that either pipe can be shut down temporarily and emptied for inspection or painting while the other remains in operation and supplies water to the plant.

The balancing reservoir into which the main pipes discharge performs the important function of keeping the flow in the pipes steady while the quantity of water taken by the wheels varies with sudden changes in load. The 28,000 tons of water in the main pipes cannot be suddenly started, nor when it is once in motion can it be suddenly stopped. The reservoir acts, then, as a buffer to make the variations in velocity demanded by the wheels apply gradually to the water in the main pipes. The reservoir at its lower end is provided with an overflow weir to take care of any unusually sudden rise in the water level. On its sides are twelve openings controlled by hand-operated gates and protected by screens which supply the 8-foot branch penstocks leading directly to the turbines. The reservoir, as a whole, is excavated in the hillside above the power house and has concrete walls resting on solid rock.

The power house is a three-story brick building with steel frame and concrete floors and roof. On the ground floor the generating units are located, and on the second floor overlooking them are the switchboard, low-tension switches and step-up transformers. The third floor is devoted exclusively to high-tension switching apparatus, busbars and lightning arresters.

There are six turbines, having a normal capacity of 6,000 horse-power



CROSS SECTION OF RAINBOW STATION

RAINBOW FALLS DAM DURING CONSTRUCTION, GREAT FALLS POWER COMPANY, MONTANA

RAINBOW POWER HOUSE, LOOKING UP RIVER

each. These machines, which were built by S. Morgan Smith Co., are of the inward flow Francis type, with two runners on a horizontal shaft. Each runner is enclosed in a separate spiral casing fed by a separate pipe from the balancing reservoir and discharging into a common draft tube. The spiral casings are of cast iron and the runners of bronze. The gates are of the wicket type, with bearings outside the wheel casing, thus insuring good lubrication. The wheels are controlled by Lombard Type N governors. A test of the wheels made under operating conditions showed an efficiency of 86 per cent. at full load; an efficiency that has rarely, if ever, been exceeded by any turbine. In the capacity test one of these turbine units carried a load of 5,500 kilowatts on one of the 3,500-kilowatt generators, showing ample capacity to drive the generators up to and above the maximum overload that would ever be put on them in regular service.

On three occasions the turbines were opened up to full gate with no load on the generators—i. e., runaway conditions—and permitted to attain as high speed as they would, with no damage resulting to any part of the apparatus and no trembling or vibration indicating an unbalanced condition in either the turbine or generators.

The turbines were closed down very quickly, so as to produce a water ram in the penstocks which showed a pressure on the gauges 100 per cent. in excess of the regular operating pressure, and no damage was done or sign of distress developed in either the penstocks, wheel cases or foundations.

Each wheel is direct coupled to an alternating current generator built by the General Electric Company and rated at 3,500 kilowatts, 6,600 volts, three-phase, 60 cycles, 225 revolutions per minute. Mounted on an extension of each generator shaft is an exciter, each exciter having sufficient capacity to excite two generators. The exciters are so connected that any one may be used for auxiliary service about the station, such as lighting, charging the storage battery, operating the crane, etc.

The station is laid out with the idea of utilizing the output of two generators in the vicinity of Great Falls, a distance of about four miles. This power is transmitted at the generator voltage of 6,600, and no step-up transformers are required. The output of the remaining four generators is stepped-up to 102,000 volts and transmitted to Butte and Anaconda, a distance of 130 miles and 152 miles, respectively. For this purpose there are installed four banks of single-phase transformers, rated at 3,600 kilowatts per bank, and having a primary voltage of 6,600 and a secondary voltage of 102,000. Five per cent. taps on the high-tension side and 3 per cent. taps on the low-tension side are provided, so that the actual voltage delivered can be adjusted and adapted to operating conditions as they may change from time to time. The transformers are connected in delta on both high and low-tension sides. All transformers and switching apparatus were manufactured by the General Electric Company. The 6,600-volt oil switches are form H-3. The 100,000-volt switches are Forms K-10 and K-15, the former being used for the high-tension side of the transformers and the latter for the outgoing lines. Electrolytic lightning arresters are used with horn gaps located on the roof of the station. The outgoing lines leave the building through oil-filled porcelain bushings in the roof.

### TRANSMISSION LINES

Power is transmitted to Butte, a distance of 130 miles, over two separate lines running parallel on the same right of way. At the centre of these lines is a switching station, equipped with oil switches and lightning arresters, by means of which a cross-over connection can be made and one-half of either line cut out while the remainder is in operation. Each line is further subdivided into seven sections by means of outdoor disconnecting switches. These switches are used for sectionalizing the line and locating trouble.

Feeding from the busbars in the Butte substation, a single line of the

GENERATOR ROOM IN RAINBOW STATION, SHOWING SIX 6,000-H. P. GENERATING UNITS

INTERIOR OF HOIST COMPRESSOR PLANT DURING CONSTRUCTION

same construction as the Great Falls line is extended to Anaconda, a distance of 22 miles, making the maximum distance power as transmitted 152 miles, and the total length of single line 282 miles.

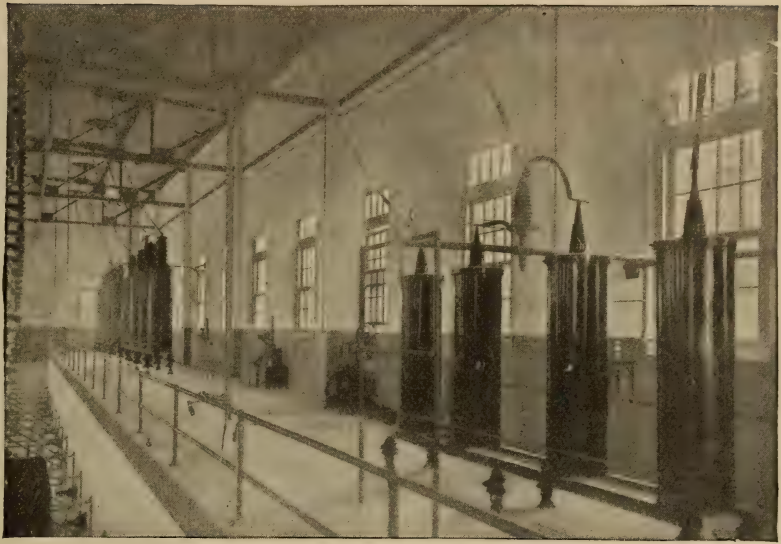
The transmission line embodies the most approved ideas in construction. The conductors are No. 0 B. & S. gauge, hard-drawn copper strand. The insulators are of the suspension type, each insulator consisting of six units, 10 inches in diameter. The insulators will stand a wet test of over 300,000 volts, and were selected after long and careful tests by the company's engineers. The wires are carried on steel towers of the four-legged, single-crossarm type, manufactured by Milliken Bros. The three conductors are suspended in a horizontal row from the crossarm, and there are no transpositions in either line. Above the power wires and symmetrically located are two galvanized steel strands, ⅜ inch in diameter, grounded at each tower, which serve as a protection against lightning.

The distance between towers in level country is 600 feet. In mountainous country, however, the spans are irregular in length, and spans of 1,500 or 2,000 feet are common. The longest one in the line is that crossing the Missouri River and is equal to 3,034 feet. The length of this span is such that a person standing at one end of it can see the wires go off and vanish into space, while the tower at the further end is barely visible to the naked eye on a clear day. The line starts at an elevation of 3,200 feet, rises to an elevation of 8,200 feet as it crosses the Continental Divide, and again descends to 6,100 feet, the elevation at Butte.

Midway between the two lines of towers a private telephone line is located. The telephone circuit is of No. 10 B. & S. gauge, hard-drawn copper, supported on 25-foot cedar poles, spaced 175 feet. The line is transposed every fifth pole, and disconnecting switches are inserted every five miles for testing purposes.

### BUTTE SUBSTATION

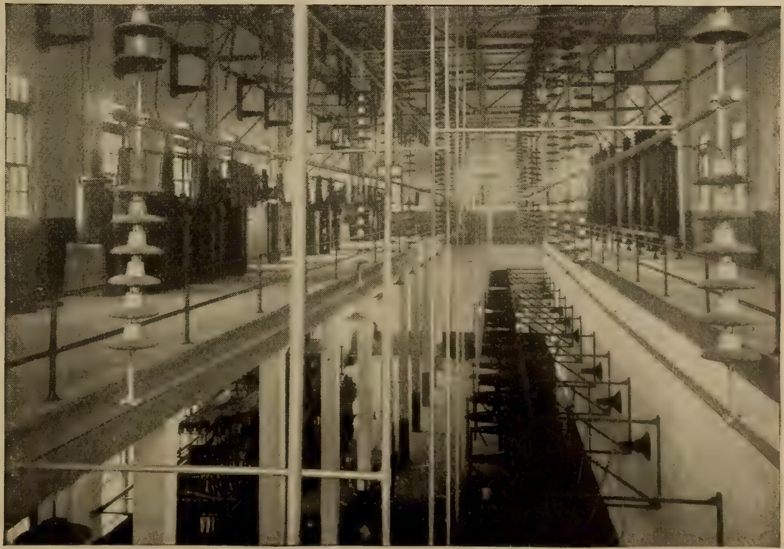
The 100,000-volt substation at Butte is located near the centre of the district in which the power is distributed. The substation building is 150 feet by 50 feet in plan and 50 feet high. It is a brick-walled, steel-



BUTTE SUBSTATION, SHOWING ELECTROLYTIC LIGHTNING ARRESTERS

framed structure with concrete floors and roof.

There are installed at present four banks of single-phase transformers, rated at 3,600 kilowatts per bank and connected in delta on both high and low-tension sides. They step the voltage down from 102,000 to 2,500, at which voltage it is distributed to customers. The transformers are installed in fireproof compartments, entirely shut off from the rest of the building by brick walls and opening only out of doors. The transformers are mounted on wheels, and can readily be run out onto a flat car, which stands on a track running parallel with the build-



INTERIOR OF BUTTE SUBSTATION, SHOWING SPECIAL BUSBAR CONSTRUCTION ing in front of the row of transformer compartments. This arrangement furnishes a convenient method of handling the transformers, both at the time of installation and afterward, in case it is necessary to make repairs.

On the gallery above the transformer compartments are located the electrolytic lightning arresters. On the gallery opposite are the 100,000-volt line switches. Possibly the most unique feature of the electrical layout is the 100,000-volt bus construction. For flexibility in switching duplicate busses are provided. The busses themselves are made of 1½-inch iron pipe suspended by standard line insulators from the roof trusses of the building. The three conductors of each three-phase bus are suspended one above another, each being supported by the next one above. The connections to the lines are also of iron pipe, making the bus structure as a whole quite rigid and well adapted to the use of suspension insulators.

The switchboard is in two sections, one section operating all line and transformer switches, which are remote-controlled, the other section taking care of the 2,500-volt feeders, which are controlled by hand-operated automatic switches.

All electrical apparatus in the substation was supplied by the General Electric Company.

The load supplied in Butte is confined entirely to the mines, the power being used chiefly for the operation of motor-driven air compressors and electrically-driven pumps. The load is very nearly uniform for twenty-four hours each day throughout the year. The load factor is, in fact, close to 90 per cent.

## COMPRESSED AIR HOISTING

Up to the present time practically all the hoisting in Butte has been done by steam.

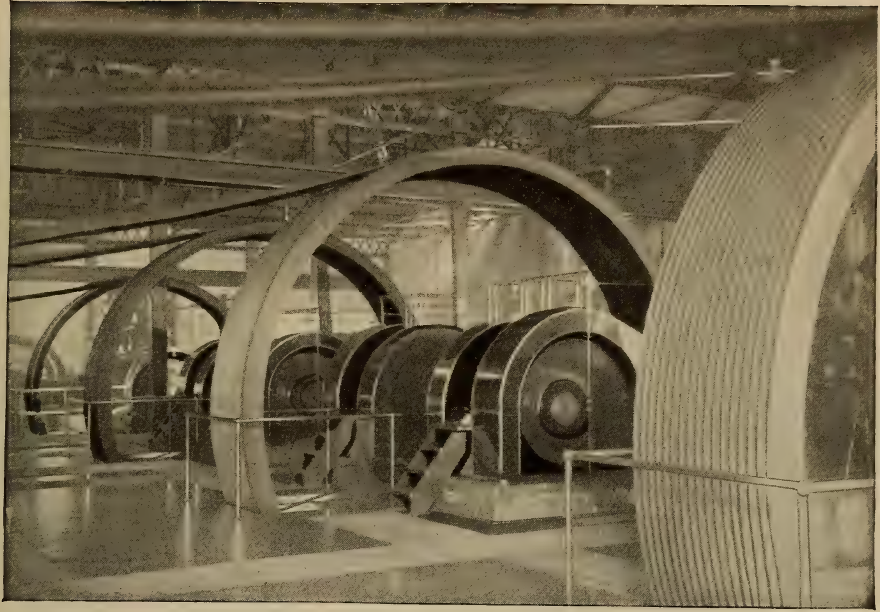
Twenty-five of the larger steam-operated hoists in Butte are driven by engines with an aggregate capacity of 40,000 horse-power. The service required of these hoists is so intermittent and the percentage of time during which they operate at full load is so small that the average power required to operate all the hoists does not exceed 4,600 horse-power. On account of the intermittent load, steam operation is very uneconomical, and it has long been desired to substitute electric power for the steam, if this could be conveniently done.

This led to the adoption of a compressed air system for hoisting, the compressed air being supplied by one large central plant with synchronous motor-driven compressors. This plant is located on top of a steep hill adjacent to the Great Falls Power Company's substation. By providing a large storage of air, a system has been worked out which will have sufficient capacity to equalize the variation in load of the entire system. On top of the hill is a steel water tank holding 60,000 cubic feet; 208 feet down the hill are air receivers having an equal capacity. The water tank is connected to the receivers, so that as air is drawn from the receivers water under pressure will take its place and maintain the full pressure of 90 pounds until the receivers are empty.

With these receivers connected to the hoisting system, not only will the load be equalized, but there will be sufficient reserve power to operate the hoist for several trips from the storage alone if in any emergency the compressor plant is temporarily shut down.

With this system of hoisting the original hoists will in all cases be used, some comparatively inexpensive changes only being necessary to adapt them to the use of air instead of steam.

Installed in the compressor plant there are at present three 1,200 horse-power, direct-connected synchronous motor-driven compressors. The motors are specified to operate at full load and 80 per cent. power

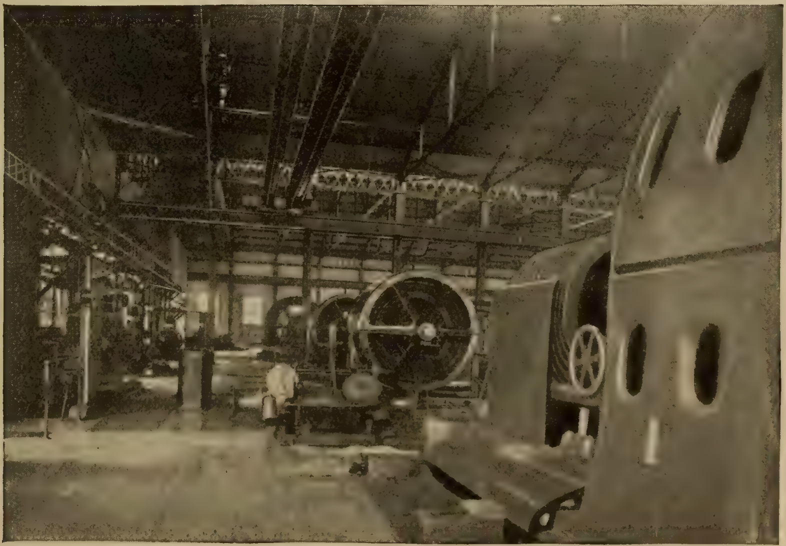


LEONARD COMPRESSOR PLANT, SHOWING 2,300 HORSE-POWER IN COMPRESSORS

factor, so that they have considerable reserve capacity for regulating the power factor of the load at Butte, thus keeping the voltage of the system constant. This is of no small advantage to the Power Company.

ANACONDA SUBSTATION

The power delivered to Anaconda is used entirely for the operation of the Washoe Smelter, the largest smelter in the world. The substation building belongs to the Washoe Cop-



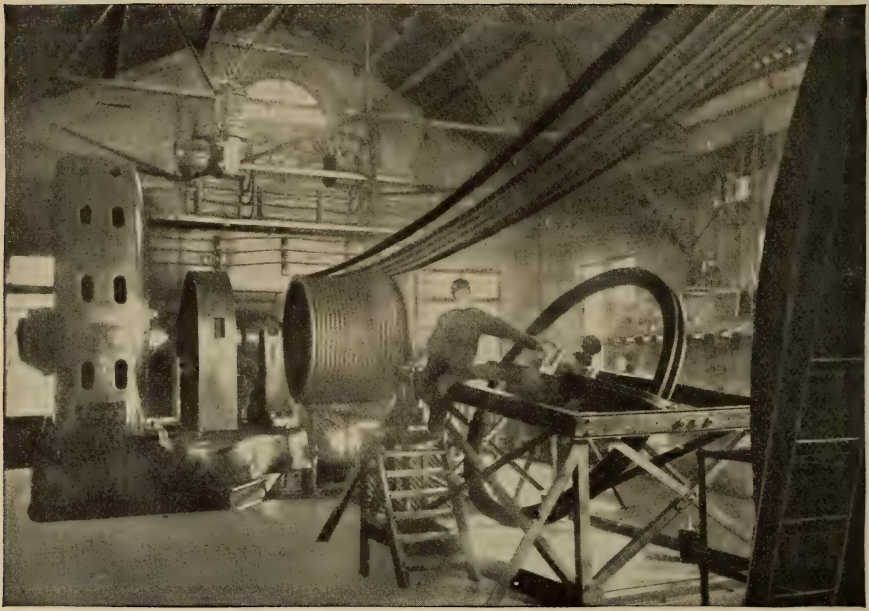
LEONARD COMPRESSOR PLANT, SHOWING 2,300 HORSE-POWER IN MOTORS per Company, and is a fireproof brick structure. There are at present installed three 1,200-kilowatt transformers, with one additional transformer as a spare. In the near future this number will be increased to six, making two complete banks, with a total capacity of 7,200 kilowatts, or 9,650 horse-power. The transformers are in every respect duplicates of those installed in Butte. They are controlled by a General Electric K-15, 100,000-volt oil switch and protected by an electrolytic lightning arrester.

The load, like that at Butte, has a very high load factor, and consists almost entirely of induction motors in large sizes.

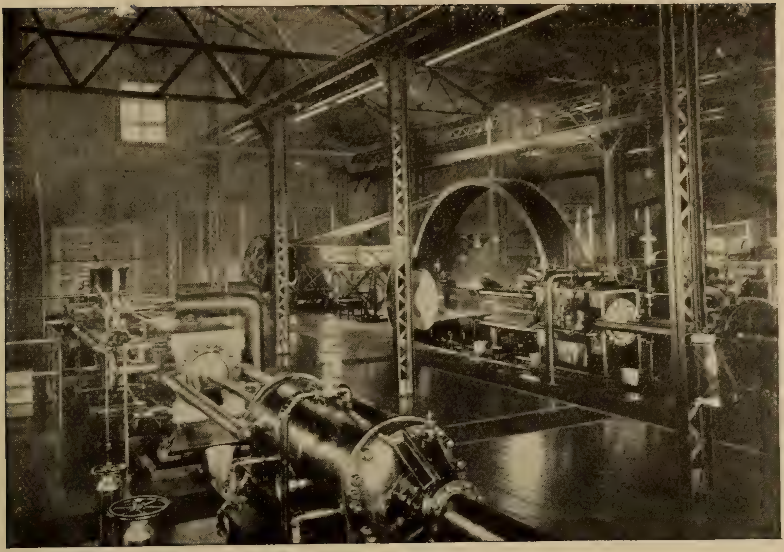
OPERATION

The load carried by the Great Falls Power Company is practically constant 24 hours a day and 365 days in the year. There are no lighting peaks, and there is no appreciable difference between the summer and winter loads. The leading current taken by the long, high voltage line just about neutralizes the lagging current taken by the load, so that the power factor at Rainbow plant is very near unity. This combination of high power factor and high load factor makes an unusually favourable condition, which is probably not excelled by any system in the country.

In addition to this, a working agreement exists between the Great Falls Power Company and the Butte Electric & Power Company, which allows an exchange of power between the systems of the two companies. This arrangement is of immense advantage to both systems. The Butte Electric & Power Company has power plants on the Big Hole, Madison, Jefferson and Yellowstone rivers, with a total capacity of 25,000 horse-power. It also has immense storage reservoirs, which allow, for short periods of time, the development of power much in excess of the low-water capacities of the plants. This excess power is at all time available for the use of the Great Falls Power Company if



NEVER-SWEAT COMPRESSOR ROOM, SHOWING 900-HORSE-POWER MOTOR DRIVING AIR COMPRESSORS



BELL AND DIAMOND COMPRESSOR ROOM, SHOWING FOUR 600-H. P. MOTORS IN OPERATION

in any emergency it should be needed.

A further advantage is that the various plants of the two systems are widely separated and are on rivers whose watersheds are subject to different climatic conditions. Thus, periods of excessive high water and excessive low water occur at different times at the different plants. If, for a few days, the flow of the Madison River or Big Hole River is less than normal and the capacity of the plants on these rivers is reduced, the deficiency will be made up from the Rainbow plant. Later, when the excessive low water is felt at the Rainbow plant, the Madison and Big Hole plants will have regained their normal output and be ready to make up any deficiency that may occur at Rainbow.

### POWER MARKET

With a power system located in the centre of a district that is growing at the rate that Montana is growing, it would be difficult to estimate the amount of power that could eventually be sold; however, this much is known: Before Rainbow plant was completed contracts had been entered into with one of the largest copper mining companies in the world, to continue during the life of the mines. Under these contracts all requirements for electric power are to be supplied by the Great Falls Power Company. To fulfill the immediate demands of these contracts nearly the entire output of the plant is required.

### PROSPECTIVE POWER

It is only a question of time when the railroads traversing the mountainous parts of Montana will be electrified, and two companies are already investigating the subject. Manufacturing industries requiring large amounts of cheap power will also increase in number, and tend to centre around the large power developments. As the country grows, the demand for power for lighting, urban and interurban railways, irrigating, milling, etc., will increase.

Great Falls is in the midst of a large agricultural region. The Power Company's lines touch upon or parallel four trans-continental railroads and one local road. The company is in a position to furnish not only cheap electric power at Great Falls, but also factory sites along the banks of the river for several miles. With unlimited amounts of power and water and good railroad facilities, this location seems ideal.

No definite figures can be given which will show the exact rate of increase in the demand for power, but with the Big Falls of the Missouri still to develop, possessing a capacity of 75,000 horse-power for peak loads, it is probable that whatever the demand may be it can be supplied for a great number of years to come.

### TRUE CONSERVATION

Much has been said of late years on the subject of conservation, many of the arguments being to the effect that water-power development should be restricted so that the people may not lose the power which Nature has given them. It would appear more to the point to argue that water-power development should be *encouraged,* so that the people may not lose the power which Nature has given them.

A few figures will show the saving that the power already developed at Great Falls will effect.

Coal in Butte and vicinity costs from $4.50 to $7.50 per ton, $5 being a fair average figure. 17.5 tons of this coal per year are required under ordinary conditions to produce one horse-power. To produce the 46,000 horse-power that is at present developed at Black Eagle and Rainbow Falls would require 805,000 tons of coal per year. At $5 per ton, this would cost $4,025,000. With further developments at Great Falls this amount can be doubled.

### CONCLUSION

It is believed that the power development herein described is qualified for the greatest success.

The immense natural falls of the river did away with the necessity of an expensive dam, and made the development exceptionally cheap. The existence of a market to take the full output of the development at the very start assures an immediate revenue and obviates the long wait suffered by most plants in gradually accumulating a load.

The working agreement with the Butte Electric & Power Company, as has been explained, is of great advantage in every way.

Last, but not least, the permanent construction of the power and sub-station insures long life and high efficiency, and it is believed that from a standpoint of mechanical strength, high insulation and electrical efficiency the transmission lines are not excelled by any in the country.

A description of this power development would be incomplete without mention of those chiefly responsible for it.

To Mr. John D. Ryan, president of the company, belongs the credit of originating the enterprise and standing back of it with steadfast support until its completion.

Mr. Henry A. Herrick, resident engineer, representing Chas. T. Main, of Boston, was in direct charge of the work at Rainbow, and largely to his experience and good judgment is due the excellence of the hydraulic design of the plant.

Mr. Frank Scotten, superintendent, carried on the construction of the plant at Rainbow with characteristic energy and completed the entire development in twenty-one months.

Mr. H. H. Cochrane, electrical engineer, prepared the designs for sub-stations and transmission lines, and helped solve many problems which arose as the work progressed.

Major George Washington Whistler, U. S. A., whose portrait we give in this issue, is a man whose name should be remembered as closely connected with the development of railways, both in the United States and in Europe. He was born in what was then the Territory of Indiana, in 1800, and received his technical education at the United States Military Academy at West Point. After his graduation he was appointed to the artillery, and remained at West Point as assistant teacher of drawing. From 1822 to 1828 he was attached to the northern boundary commission, and in 1838 he resigned from the government service and began to take an active part in the construction of railroads, being connected with the building of the Boston & Providence Railroad and with the Western Railroad of Massachusetts.

In 1842 he went to Europe and became consulting engineer to the railroad department of the Russian Government, then beginning to take an active interest in railway construction, and acted as civil engineer in consultation with Count Kleinmichael, General Melnikoff, and other Russian engineers in the construction of the permanent way of the railway from St. Petersburgh to Moscow. For his services in connection with the development of railways in Russia, Major Whistler received the Cross of the Order of St. Ann from the Emperor Nicholas I. Major Whistler continued in the service of the Russian Government until his death, which occurred at St. Petersburgh in 1849. The railways with which he had so much to do in Russia were equipped with rolling stock constructed at the government works at Alexandroffsky, near St. Petersburgh, under contracts with American engineers, Messrs. Harrison, Winans & Eastwick. Major Whistler had several children, the most noted being the late James A. MacNeill Whistler, the artist.

MAJOR GEORGE WASHINGTON WHISTLER, U. S. A.

See Reverse Side

INDEXED

# CASSIER'S MAGAZINE

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# THE DRIVING OF COTTON MILLS

By **W. H. Booth**

In selecting motive power it is always desirable to consider the peculiarities of the industry involved, and thus be able to meet all the requirements. There has been some discussion as to the relative advantages of belting, rope, or electric motors, for driving cotton machinery; and, in the present article, Mr. Booth shows the reasons why the steam power plant, with rope transmission, continues to be held in favour in England. Approaching the subject from an independent standpoint, he presents both sides of the case, while the illustrations show the extent to which the steam engine and the rope transmission have been perfected in this department of industry.—THE EDITOR.

THE driving of English cotton mills is a somewhat vexed subject at present. There are two schools of opinion—that which advocates the use of rope driving from the flywheel rim of a modern large quick-speed compound or triple-expansion steam engine and that which advocates electrical driving. Of this school there are two divisions—the one which would generate electricity at the mill itself and the one which advocates the purchase of current from an outside station, perhaps some miles distant. The load factor of a cotton mill must certainly be more than 90 per cent., that of an outside general power station is almost certainly less than 50 per cent., and this is regarded by the one set of partisans as fatal to internal generation, for they argue that there is no saving in labour at the mill where the machinery will still call for the payment of an engineer and the mill heating will still demand boilers and a fireman. This school of opinion, in short, recognizing that a mill, especially when spinning the fine counts usual in England, must still be heated, simply advocate the substitution of ropes and pulleys for electrical conductors and motors. But even here divergence of opinion does not end, for some would abolish all shafting, while others would leave the shafting as it is, arguing that the machinery in a cotton mill is so closely packed that there is very little length of shafting to each machine, and that to displace, say, the shaft which drives a carding engine and put in its place a small, more or less efficient, motor and a short stiff belt, will involve a much greater loss of power that lost by a few feet of shaft and a long, easy belt. For driving ring frames a system has been evolved for varying the speed of the machine as the diameter of the bobbin or pin of yarn increases and the pull on the yarn varies owing to the change of angle of the yarn between the traveler ring and the spindle. This speed variation is most easily effected by means of electrical driving, and, indeed, seems, to justify the generation of electricity for this one room of machines in a factory otherwise wholly rope-driven.

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Some machines start to run when the engine starts and do not stop unless and until the engine stops. Such are the cards. Others stop when the spindles are full. Such are the ring frames. Others, again, such as the slubbing and roving frames, stop if a sliver breaks. It is argued that electrical driving should at least be employed for this last class because by its means the frame can be more rapidly set in motion again. But, again, others say that a frame can already be started sufficiently quickly by the present belt and that the claimed advantage is chimerical. They also aver that with a motor to each machine every motor must be big enough to give the necessary starting torque and that this implies a very large additional power of motors and thus the motors are much too large for their normal load and must waste power in needless friction, whereas a belt will do the starting work and will not lose by friction at the normal speed. There is thus great diversity of opinion and practice. It is also alleged on behalf of rope driving that all instances of superior output from electrically-driven mills have been made as between electrical driving and very old-fashioned mechanical drivers with slow-going, old-type engines.

Since there is required to drive a factory of 70,000 spindles a power of something like twelve to seventeen hundred indicated horse power, calling for from 30 to 50 tons of coal per week, the engineering department is by no means of small importance. Cotton mills may be driven by four systems: (a) by gearing, the spur-toothed rim of the engine flywheel driving a pinion on the shaft, on which is a bevel gear driving a similar wheel on an upright shaft extending to the top of the mill and driving a line shaft in each room. As regards power consumption the method is, perhaps, the most economical, but it is now practically obsolete. (b) The wide belt began to supersede the above spur-geared flywheel system about thirty years ago, but it still required the aid of a good deal of a toothed gearing and shafting to carry power from the second motion shaft to the different rooms, for the main belt system did not lend itself well to subdivision, and belt driving, before it was fully established, was superseded by (c) the rope system, now most usual. In this system a heavy multiple-grooved fly rim on the engine shaft carries some thirty to forty ropes of cotton 1⅝ or 1¾ inches diameter, each capable of transmitting 40 to 50 horse-power, at a velocity of 4,000 to 5,000 feet per minute. Opposite the face of the wheel is the rope race, a little wider than the fly rim and extending to the top of the factory. Across it extend the ends of the shafts from each room, each with its smaller grooved rope pulley. To each of these extend the proper number of ropes from the engine driving rim according to the amount of power required by each room. In Fig. 1, which shows the rope system of a 1,200-horse-power engine, there are eleven ropes from 115 feet to 186 feet in length to the three shafts in the lower room and six ropes 178 feet long to the second room.

There are five ropes 186 feet long to the third room shaft and there are nine ropes of 161 feet and 198 feet to the two shafts of the fourth room. There are three ropes to one shaft and five to another, and there is a two-rope horizontal transmission of 95-foot ropes to a third shaft, which could not be driven directly from the large rope pulley because of the interference of the shaft in the room below. The pulleys in the three upper rooms all have a diameter of 4 feet 5⅜ inches, to run at 350 revolutions per minute, and those in the lower room are 6 feet 2⅞-inch diameter and run at 250 revolutions per minute. Where there is more than one shaft in a room the other parallel shafts may, as shown, be driven from the main shaft by ropes of the same sort.

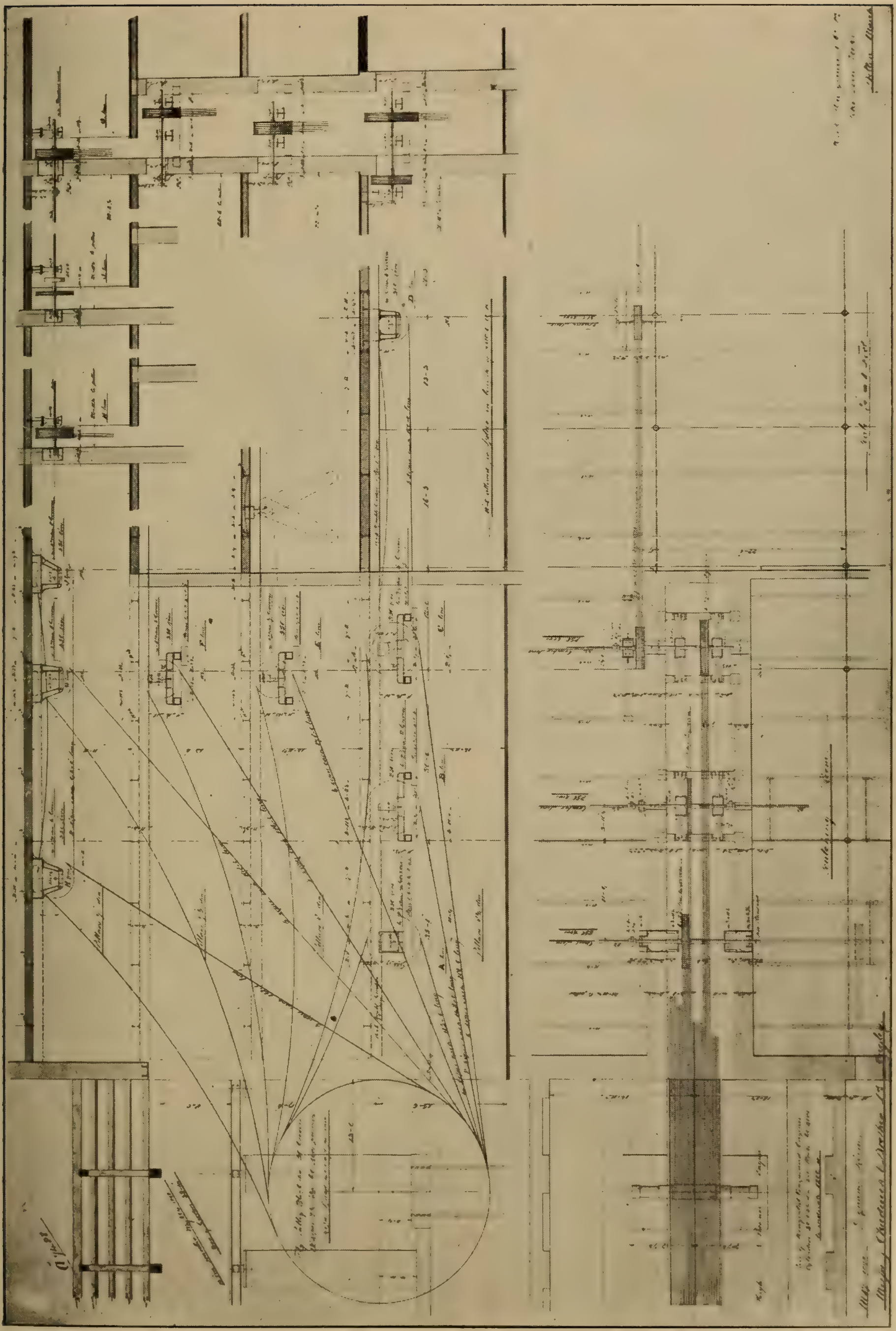


FIG. 1.—ROPE DRIVE OF 1,200 HORSE-POWER FOR COTTON MILL

Where the scutching department occupies one end of the mill beyond the rope race, the necessary shaft is continued through, as shown in this same illustration, while another shaft is continued through and drives by a horizontal rope from the scutching room to the dynamo room, driving the dynamo for the electric lighting. The main pulley is 26 feet diameter and has thirty grooves for 1½-inch ropes at 2 5/16 inches pitch to run at 4,900 feet per minute. One line of the shafting in the lower room drives the carding engines, two lines drive the combs, and the further shaft drives the frames and runs at 300 revolutions per minute.

The latest systems of power distribution are (d) electrical. In one method there may be a motor on each line shaft, current to this being transmitted by cables either from an electricity generating plant in the mill itself or from an outside power station. In Italy it is usual for practically every machine in the mill to be driven by its own motor, thus abolishing shafting, belts and pulleys, but this system is more costly to install than that of line shaft with larger motors. Much of the Italian driving is also from hydro-electric power stations and only electrical systems would usually be possible. It is claimed for electrical driving that the output of a mill will be increased by as much as 5 or even 7 per cent. as compared with rope driving, though it costs more than rope driving to install and to run, and against the rope friction is to be set the loss in the electrical cables and in the motors themselves.

It does not at present appear that an outside power station can supply electricity as cheaply as it can be generated by the factory itself, but the chief objection to an outside source of power is that the necessity for mill warming will still require the presence of steam boilers at the factory, of firemen, and other labour, so that the purchase of electricity does not tend towards any simplification.

The engines for a cotton mill are very commonly of twin-compound tandem type (Fig. 2) with the rope rim between. The low-pressure cylinder is usually placed tandem and behind the horse-power high-pressure cylinder and the air pump is driven from the lower-pressure crossheads with links and an L lever. The working pressure is 160 pounds, the cylinder diameters 21 inches and 43 inches, and the stroke 5 feet for, say, 1,700 or 1,800 horse-power. On a two-cylinder, side-by-side compound engines may be employed (as in Fig. 3) with cylinders 30 inches and 56 inches and a stroke of 5 feet for, say, 1,200 horsepower, with the air pump driven off the low-pressure crosshead, as above.

The speed of rotation in this case is 60 per minute and the indicated horse-power 1,200.

It will be observed that the line shafts are carried in long bearings fixed upon supports carried by a pair of beams that are built into the walls of the rope race and bedded on large stone 9 inches thick built into the walls. There is an oil system of pipes to every bearing, the oil being supplied by a rotary pump to an upright main, from which branch pipes are taken to each bearing. The returned oil flows by a down main and passes under pressure through a filter and back to the pump, a constant and copious supply being maintained.

There is and always has been considerable discussion and difference of opinion as to the proper and best velocity for ropes. Nominally the power of a rope varies as its velocity, but it is to be remembered that a rope is subjected to the action of centrifugal force as it travels round its pulleys. Centrifugal force varies, as the square of the velocity is that with the rope stresses commonly allowed, the increase of the centrifugal stress for any velocity beyond 80 or 84 feet per second more than outbalances the increase of capacity due to the additional velocity. Others affirm that the ropes are gripped so fast in

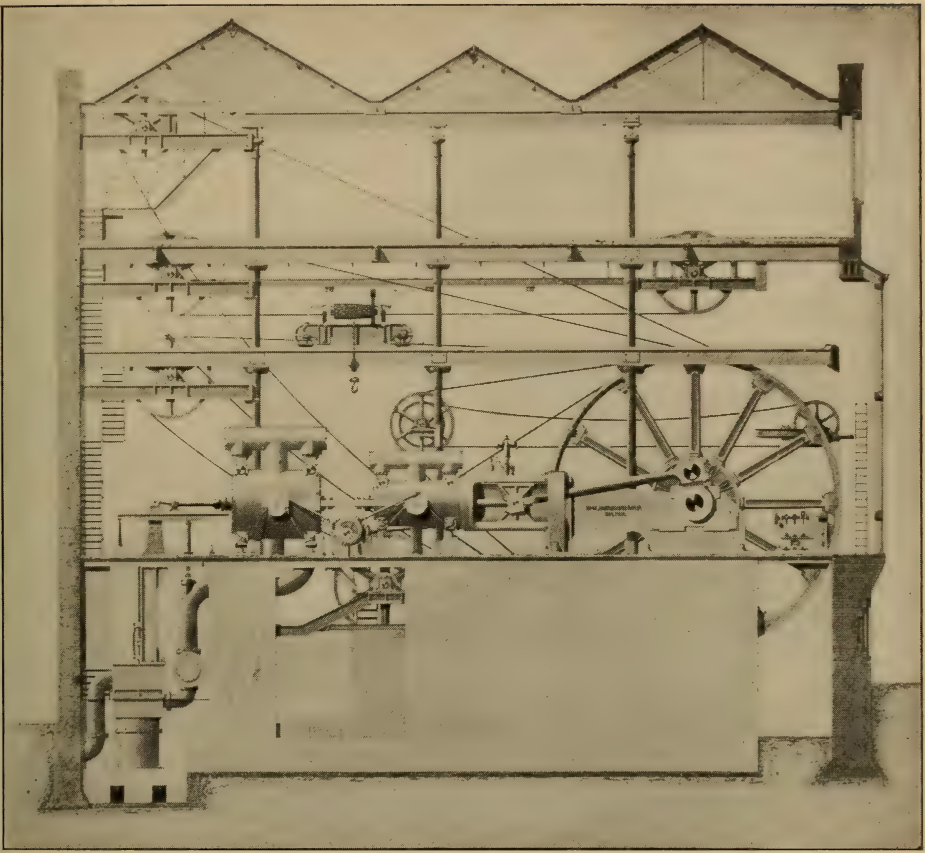


FIG. 2.—ARRANGEMENT OF DOUBLE TANDEM COMPOUND ENGINE INSTALLED IN AN OLD MILL

the grooves of the pulleys that centrifugal tension is eliminated, and they claim as proof that there are ropes which run at 6,000 and 7,000 feet per minute with every satisfaction. The writer pointed out twenty years ago that there was little to choose between speeds of from 3,600 to 4,800 feet per minute, and the eminent firm of engineers, Hick, Hargreaves & Co., of Bolton, say that nothing is really gained by going beyond 4,000 feet per minute in respect of the capacity. Fig. 4 of the Osaka Mill, No. 3, shows how a rope speed of 4,398 feet per minute has been worked in with an engine speed of 70 revolutions per minute and a 20-foot rope rim with 28 grooves.

In Fig. 5, also from Hick, Hargreaves & Co.'s practice, is shown the oiling system for ¾-inch pipes to the shaft necks. The illustration also shows how the 40 ropes are carried to the four rooms. All the pulleys are 6 feet 2, and their speed 250 revolutions per minutes, except the outer shafts in the first spinning room, which have a horizontal subsidiary drive and run at 300 revolutions per minute.

In Fig. 2 is shown how a new engine and rope drive has been put into an old mill. It may be added that no trouble is found to arise from the running of the ropes in the opposite direction from that usual; that is to say, the outer side of the rope loop is in this case the driving side, the usual practice being to drive through the lower loop, whereby the arc of contact of ropes and rim is a maximum, and it is considered that there is least risk of a rope leaving its groove. In the particular case illustrated in Fig. 2 the reversed method was thought to involve the minimum of expense and inconvenience, though, of course, it would not be chosen in ordinary new construction.

As regards the type of engine to be employed, there has of late been a tendency to use vertical engines and to employ triple expansion. It is a question whether there is any commercial advantage in either of these two departures. Vertical engines require less floor space, but they are much less convenient to handle and overhaul. They have the somewhat visionary advantage that their pistons float in the cylinders which are not rubbed heavily by the piston body. But what are the facts as to the horizontal engine? Do the pistons bear heavily on the cylinders? They need not. The piston rods are continued through the back covers of their cylinders and there is a back slipper guide to carry the weight of the rod and of the piston. Now, a straight rod can carry no load. All the weight of the piston must be carried by the cylinder. How is this undesirable load to be transferred to the two end slipper guides? The solution is simplicity itself. Let it be supposed that the rod will deflect, say, one-quarter of an inch when carrying itself and the piston. The rod is placed between two supports and hydraulic pressure is brought upon it and it is bent one-quarter of an inch upwards. This is carefully done until the upward camber of the rod is such that when loaded by the piston the rod is straight. By this means all the deflection is removed and the piston load is transferred from the cylinder bottom to the slipper guides which are outside the cylinder, cool and fully lubricated.

As an example of large mill engines may be cited those of 2,000 indicated horse-power built by Hick, Hargreaves & Co. for the Gourepore Company's jute mill at Naihati, Calcutta. These engines are of compound type with cylinders 35 inches and 65 inches diameter and 6 feet stroke. They run at 55 turns per minute and drive a 28-foot drum, grooved for forty cotton ropes 1¾ inch diameter. The drum weighs 65 tons, and, while 2,000 is the economical power, there is a margin of 660 horse-power in case of need. There are two air pumps worked from the tail rods, and a central jet condenser, and the cylinders are jacketed on the "thoroughfare" principle with boiler pressure steam of 130 pounds pressure, and there is a large receiver near the horse-power cylinder to serve as a water separator and to prevent undue pulsation in the steam main. There seems very little room to doubt the general superiority of the compound over the triple engine for textile work. Triple expansion engines certainly work with less steam per indicated horse power, but for a given duty in spindles turned they show more indicated horse power; they cost more and they do not, especially with superheated steam, justify this expenditure, in any commercial economy they obtain.

Steam is tangentially admitted to the horse-power jacket at the bottom and passes to the admission valves at the top of the cylinder and away by the exhaust valves at the bottom of the cylinder. The drains discharge by traps to atmosphere both from the jackets of the cylinder and of the intermediate receiver, while the low-pressure drains may discharge either to the atmosphere or to the condenser. The admission valves lift freely off their seats so as to afford an enormous relief way in event of water accumulating in the cylinders which cannot be properly dealt with by the paltry spring relief valves so often seen pitted. Corliss valves were once made as large as their chests and had no room to rise, but as now made by Hick, Hargreaves & Co. they are worked by spindles, which have a bearing in the back bonnet also, wherein is provis-

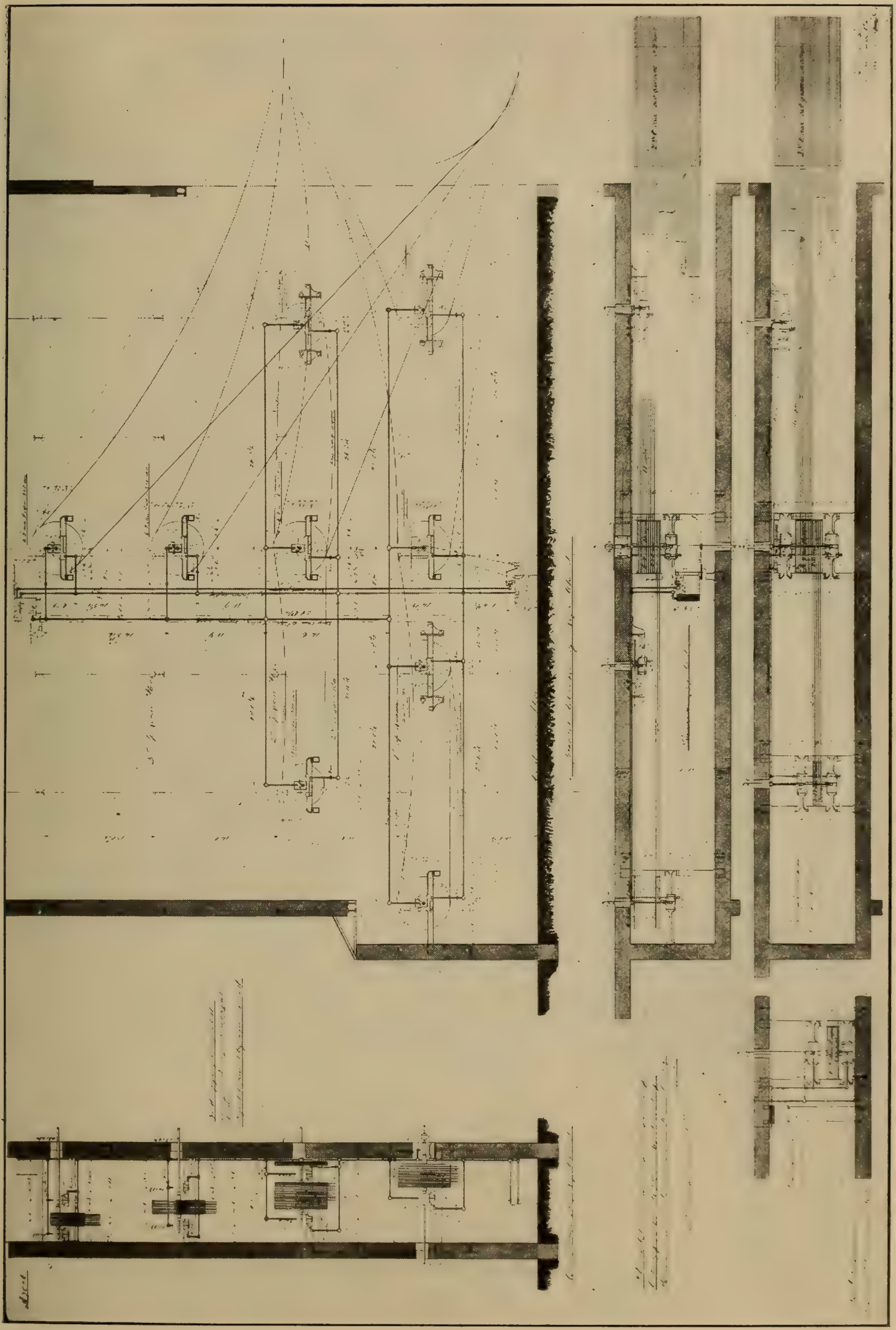


FIG. 3.—SHOWING OIL PIPE ARRANGEMENT TO SHAFT BEARINGS IN ROPE DRIVE. HICK, HARGREAVES & CO., LTD., BOLTON

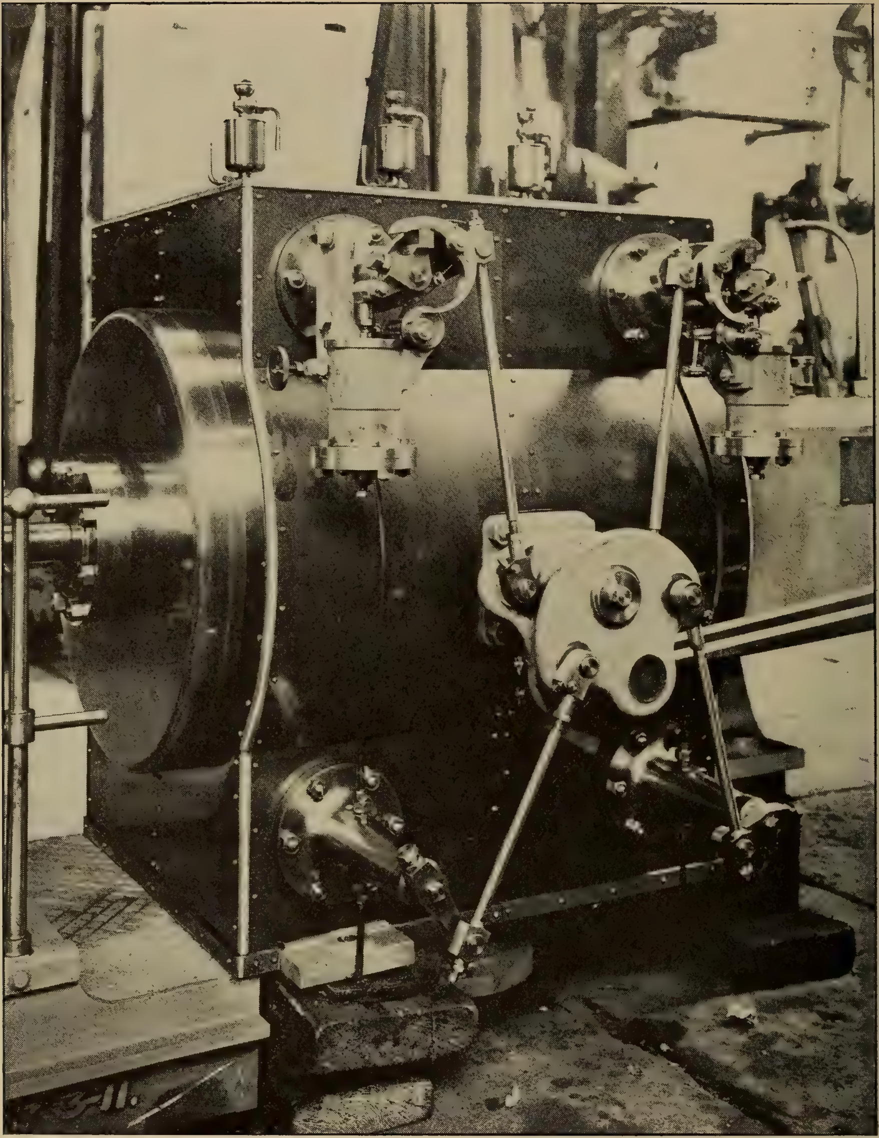


FIG. 5.—DETENT GEAR OF CORLISS VALVE. HICK, HARGREAVES & CO., LTD., BOLTON

ion for expansion and steam tightness about the end of the valves. The piston rod metallic packing also floats about the rods. The cylinder barrel is a plain casting held between separately cast ends, and the crank shaft, of Siemens-Martin steel, is always bored through from end to end as a proof of its internal freedom from flaws. It runs in bearings which can swivel so as to give a full, even bearing to the shaft necks, thereby obviating the packing of the outer edges of the main pedestals to allow for the deflection of the shaft under its heavy load of flywheel. The valve gear eccentrics are driven by a shaft and bevel wheels from the main shaft. This permits eccentrics of reasonably moderate diameter to

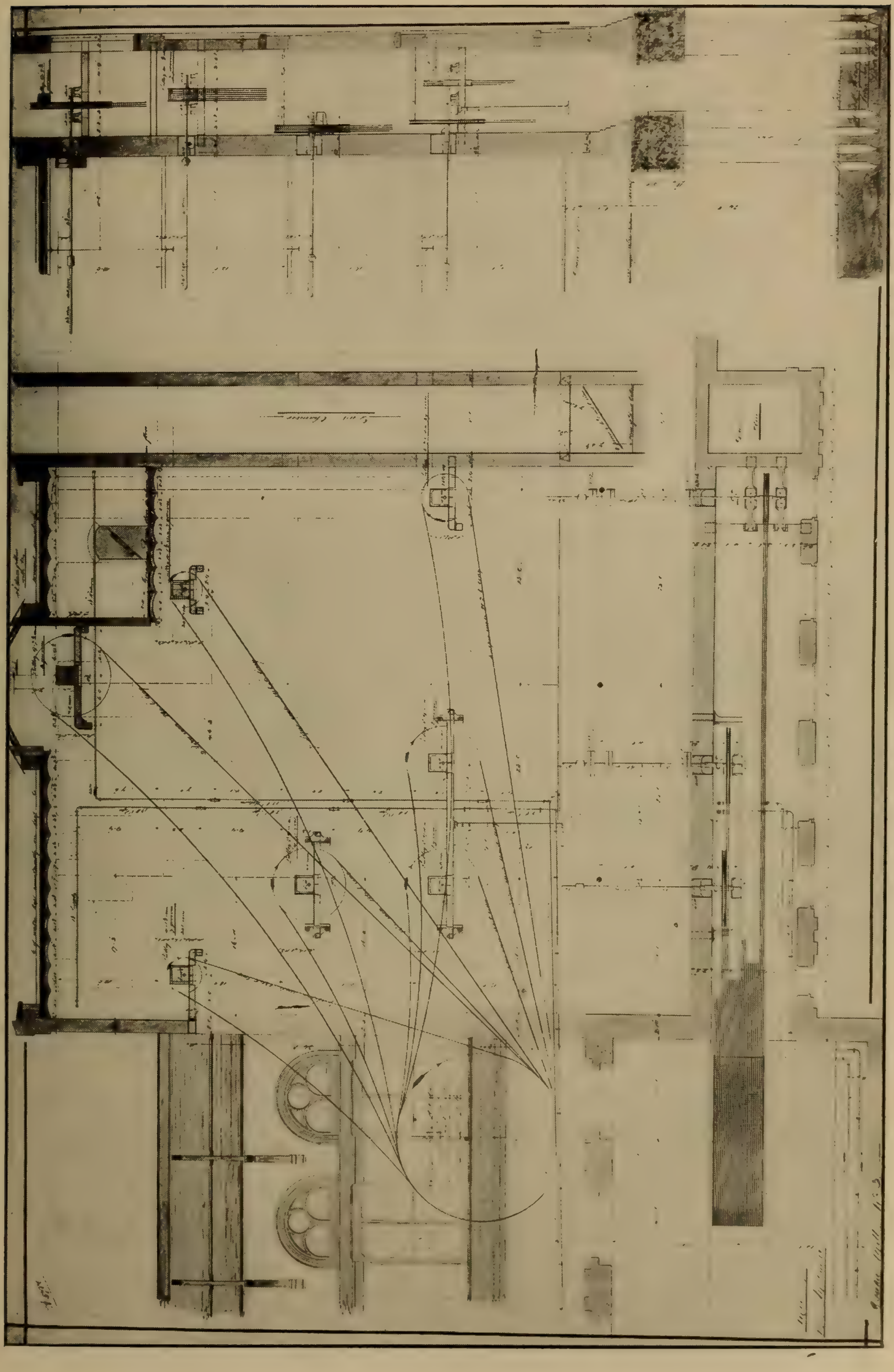


FIG. 4.—TRANSMISSION SYSTEM OF THE OSAKA MILL, JAPAN

be employed, and enables the eccentric rods to be kept as short as they are required to be. The governor has a safety appliance which cuts off steam should the speed become excessive, and it cannot be rendered inoperative except for the short time when stopping the engine, for it automatically resets itself to safety.

Tests of two engines of this type of 1,300 and 1,600 horse-power respectively showed that the friction loss was 5.85 and 8.8 per cent. respectively. The steam consumption is about 14 pounds per indicated horse-power hour with a boiler pressure of 120 pounds and 13 pounds with a pressure of 160 pounds. A prolonged test with superheated steam upon an engine of 1,400 horse-power showed only 12 pounds of steam per indicated horse-power hour. Tubular reheaters have been recommended to give even better economy, but they introduce this danger that if a tube leaks, as it may do inwardly, it might supply steam enough, beyond the control of the governor, to cause a runaway at light load unless the low-pressure valves also are under the governor control, as is now sometimes the case.

The cotton driving rope has the desirable virtue that it never breaks suddenly. It fails gradually, stretches out and shirks its work, and throws out short strands of loose ends. Advantage is taken of this by laying a light rod across the face of a rope drum and so close to it that, as these loose tags of rope come round, they strike this safety bar and actuate the knock-off gear which stops the engine. Every engineer knows the form of the Inglis and Spencer Corliss gear —the release springs—as made by Hick, Hargreaves & Co. from the time they first began to make the Corliss engine in Great Britain. This gear was never surpassed and only since it has seemed desirable to run the Corliss engine at higher speeds has a want been felt for a better detent motion. Several were tried

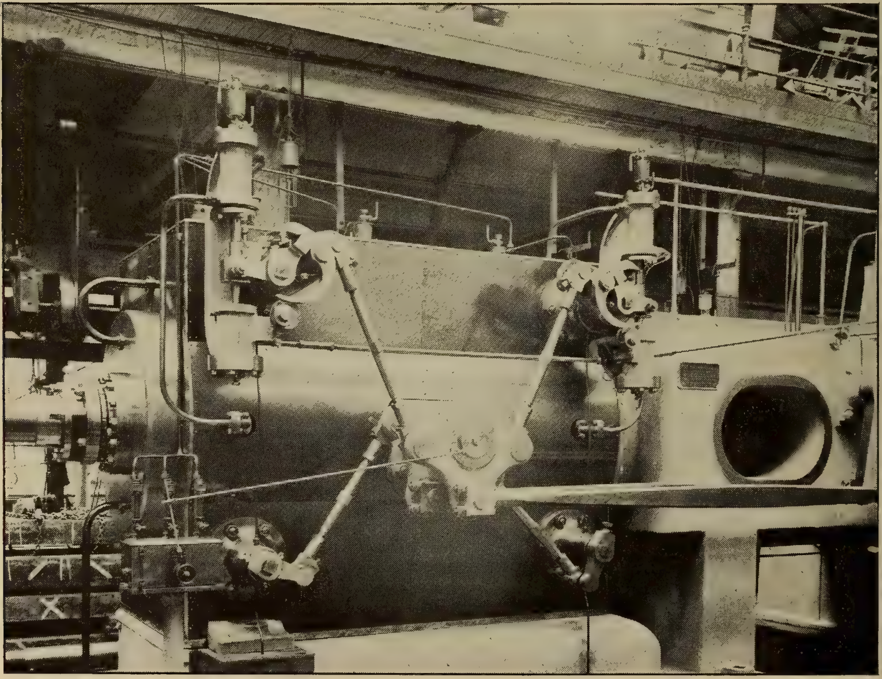


FIG. 6.—CORLISS GEAR WITH STEAM DASHPOTS. HICK, HARGREAVES & CO., LTD., BOLTON

and exhaustively tested and the survivor is that shown in Fig. 5, which the writer has seen at work on engines running at 125 revolutions per minute. It is so simple and compact that it is a marvel it was not sooner thought out. But when really required it was duly thought out. It is in the form of a sickle, the release spiral—for it is a spiral crescent that runs over the releasing bowl, plainly visible in the illustrations—serving to lift the opposite end of the sickle off the detent edge of the valve spindle rocker.

The releasing bowl pins are placed eccentric to the spindles on which they are carried so that as those spindles are rotated through a small angle of the governor the bowls are approached to or receded from the release crescent and the cut-off is thus varied without imposing any duty on the governor. The attachment to the governor is only plainly seen in Fig. 6, in which appears on the right the inclined rod to the governor and the horizontal rod which connects the two levers. There are steam dashpots to the gear, and the quietness of working is as remarkable as is the compactness and complicity.

In the engines illustrated in Figs. 7 and 8 the eccentrics are on the main shaft; the rods are short and movement is conveyed to the valve rockers by parallel bars, as shown most clearly in Fig. 8. Since these big factory engines must be barred slowly round it is necessary to provide means for doing this more easily than can be done by a hand bar.

Engines are barred round slowly in order that they may be uniformly warmed before starting. They have to be moved round when examining pistons and air pumps and when adjusting valves, and also when repairing or replacing ropes. Barring is no easy work and a steam-barring engine is a necessity In that of Hick, Hargreaves & Co. there is a toothed ring inside the great rope drum and into this ring engages the wheel of the little two-cylinder barring engine. This wheel is driven by a worm and is carried on a centre pin in a slotted bearing. When barring the engine round for putting it into starting position steam is, say, already on the high-pressure cylinder, but the crank-

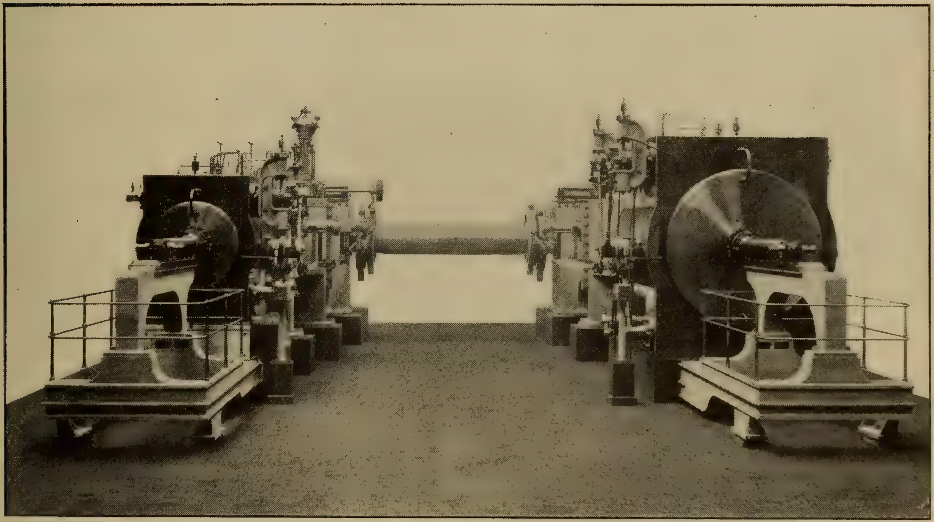


FIG. 7.—CROSS-COMPOUND HORIZONTAL CORLISS ENGINE. HICK, HARGREAVES & CO., LTD., BOLTON

pin is at the dead centre. The worm pushes the barring wheel forward when in gear with the rope rim and holds it in gear by the force necessary to turn the big engine, but as soon as the big engine begins to move itself it drives the barring wheel, and now the worm becomes the fulcrum and the barring wheel slides back on its bearing, being helped by a spiral spring, and falls out of gear with the rope rim.

The barring wheel is put into gear with the rim when wanted by holding it fast at its lower edge by a friction pad held on by a lever. It holds itself in gear when turning the rim, and the friction lever may be released. To prevent the barring engine running away when it is thrown out of gear it is made with very small steam ports and cannot get steam enough to enable it to move quickly.

The resistance of a dead engine and shafting is, no doubt, considerable, but, of course, at a low velocity, and the power to move it is proportionately less. Still, a barring engine has considerable work to do even at the slow rate of rotation required, and must be of adequate size, since it is often needed after hours when the boiler pressure is low and it is required to move the engine slowly round.

For a mill of 1,200 or 1,300 horsepower there will be three 30 feet by 8 feet 6 inch Lancashire boilers, one being spare, of the type shown in Fig. 9. In each back downtake flue may be placed a superheater and in a modern up-to-date mill this may be water controlled on the Cruse system, the temperature of superheat being about 500 degrees Fahr., with a variation of 10 degrees Fahr. to 20 degrees Fahr. Heat accumulator superheaters cost less, having cast iron heat accumulator cores which, though affording better regulation of temperature than any entirely uncontrolled superheater, are not so efficient as the water-controlled apparatus.

The feed water is heated by a Green's economizer of 240 to 360 pipes and the waste gases flow to a chimney of 200 to 250 feet high and 8 feet internal diameter.

With such an up-to-date steam plant the coal consumption for indicated horse-power will vary from 11 pounds to 12 pounds per horse-power hour in summer up to 13 pounds to 15 pounds in winter.

Warming to a temperature of 98 degrees Fahr. for five counts is necessary to good work, and the atmosphere should not be dry or the cotton fibres become harsh and nonpliant, do not work well and much waste is produced in every process. Humidifiers are necessary to raise the atmosphere to about 70 or 75 per cent. of saturation.

Owing to the great amount of window surface there is much cooling by radiation.

Since there is practically no work locked up in the yarn produced all the power that enters a mill is, within a small fraction, converted into friction-generated heat and the mill is warmed sufficiently by this in mild, warm weather. If 800 horse-power be assumed to be let loose in a mill this represents about 2,000,000 B. T. U. per hour, or the equivalent of 150 pounds of fair coal, or, say, about 4 tons per week wholly turned into heat in the mill itself. About sixteen million B. T. U. of heat are hourly discharged into the hot well from the engines, and it does seem strange that use is not made of this waste heat to warm air to be discharged, suitably moistened, for heating and ventilating purposes. The total heat put into a 70,000 spindle mill amounts at times to about seven millions B. T. U. per hour, so far as can be approximated from a knowledge of the frictional heat and the coal burned purely for mill warming purposes. Thus five, or at most, say, six million units would be required of the sixteen million units that goes to waste in the hot well. A standard mill could save as much as 12 tons per week by a rational system of warming by

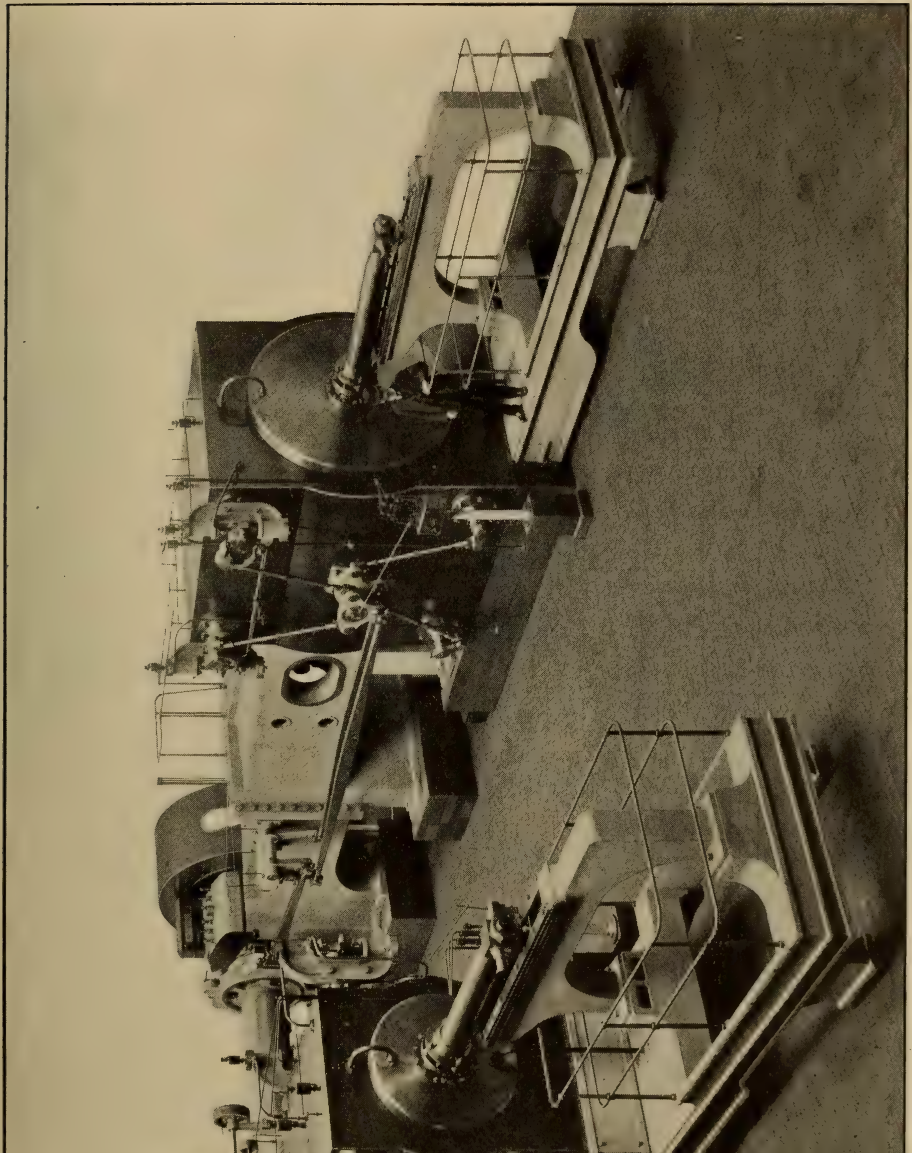


FIG. 8.—CROSS-COMPOUND HORIZONTAL NEW CORLISS ENGINE. HICK, HARGREAVES & CO., LTD., BOLTON

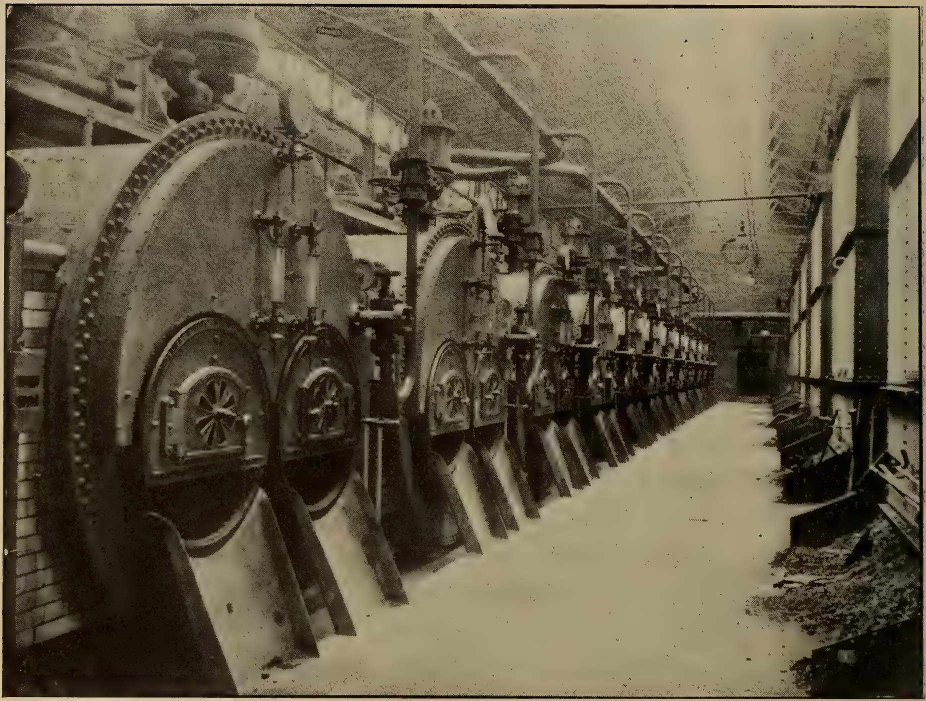


FIG. 9.—ROW OF 12 LANCASHIRE BOILERS, 30 FT. LONG BY 8 FT. 6 IN. DIAMETER. HICK, HARGREAVES & CO., LTD., BOLTON

the waste heat of the main engines.

One reason for the great success of rope driving has been its cheapness; another has been the fact that the ropes are made of cotton, but the main reason has been probably the very even regular turning given as the result of the great weight of the fly rim and its high velocity. Steady turning conduces to economy of production, small wastes and large output per spindle. If there is any pulsation of effort at the engine cranks and this is not damped out by the flywheel, the impulses are multiplied at the ends of the long line shafts, and, in old mills, with light and slow running flywheels the revolution of the engine could be counted at the frames by the difference of hum. No difference of note can be detected in a modern rope-driven mill, and this rather disproves the claim that an electrically-driven mill is more steadily driven than one driven by rope.

Though the driving of a mill by purchased electricity is likely to cause either the mill or the power station to be a loser by the transaction there is no reason why a group of mills within easy reach of each other should not be driven from a common central power house with arrangements for the warming of air to be supplied to each mill so that no boilers or chimney would be required. This scheme, to be most successful, presupposes a site of sufficient area for ten or more factories with one power house. But there are existing groups that could be thus arranged fairly well under present conditions. This, however, would scrap the existing plant, and it cannot be shown that it would pay to buy current at the cost of scrapping good plant. The new system suggested should be ready for trial when the next boom in mill building comes round.

Approximately the cost of the mechanical driving plant for a spinning mill of 110,000 spindles will be

£18,435, the driving being by ropes and the engine of 1,500 indicated horse-power. The annual running costs, with coal at 12/6 per ton, will be £5,559, or equal to 0.477 pence per kilowatt hour.

An electrical installation at the mill itself with a turbo generator of 1,000 kilowatt capacity will involve an expenditure of £21,330 and an annual cost, including as in the mechanical driving the capital charges, of £6,281, which represents 0.534 pence per kilowatt hour, and to this should probably be added the cost of a 75 kilowatt combined lighting set, for it is hardly satisfactory to run lights from the same three-phase power generator. This will cost £560 and will raise the cost about 1 per cent.,

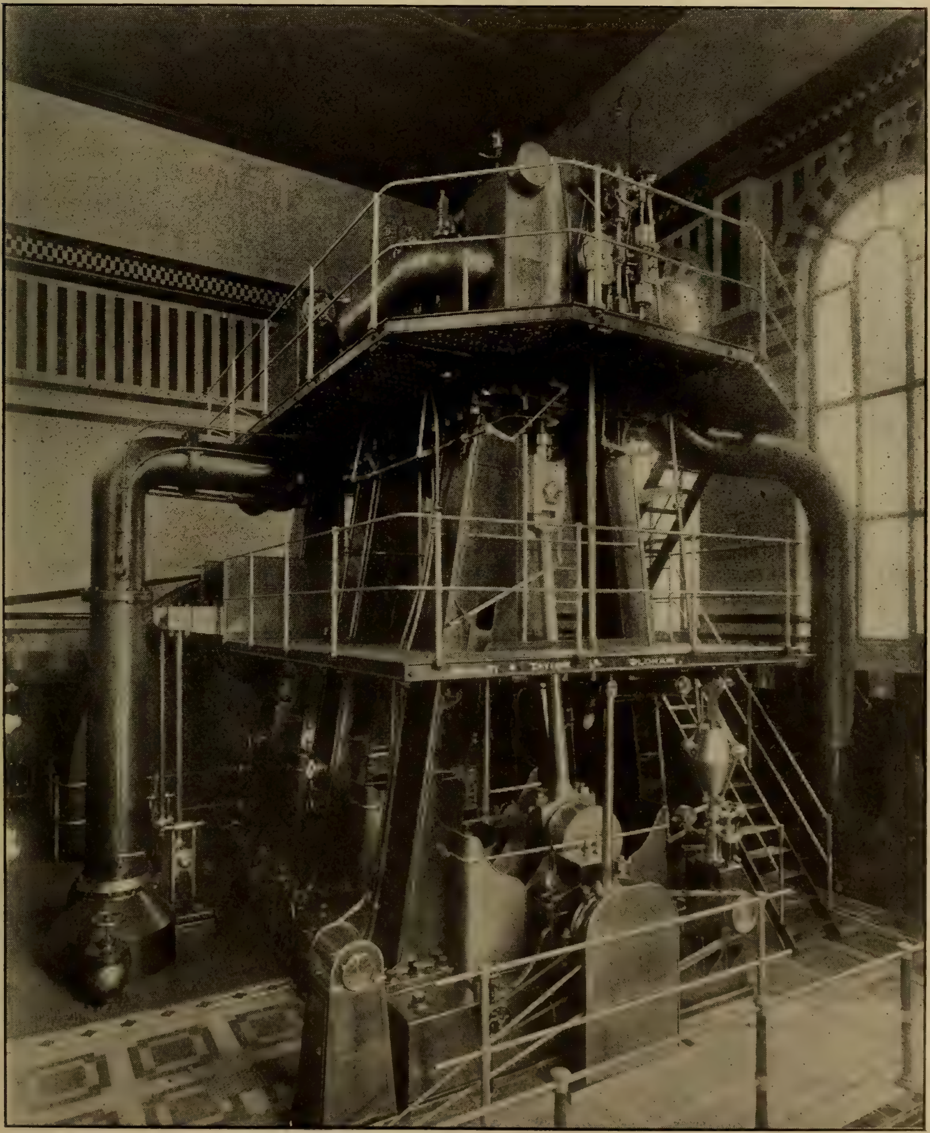


FIG. 10.—VERTICAL MILL ENGINES BY BUCKLEY & TAYLOR, LTD., OLDHAM

or to about 0.540d. per unit. For current purchased outside the capital outlay at the mill will be reduced to £9,280 and the annual costs will be £7,680:10:0 with the price of current 0.5625d. per unit.

This represents 0.657 pence per kilowatt-hour and appears effectually to bar out of competition the use of purchased current at any price at which its supply will pay any yet existing power station to afford.

Investigation of the subject of electrical driving fails so far to turn up any evidence that driving a mill electrically is more steady than driving it by ropes. Comparison may be found, it is true, where the superior turning afforded by electrical plant driven by a modern engine with three cranks at 125 revolutions per minute produces results that are better than those produced from an old two-crank engine running at 40 revolutions per minute and very much out of balance; so much so as to be plainly discoverable by ear alone. But there is no evidence of superior output, as compared with a rope-driven mill equally modern in its engine room.

Again, where spinning frames (rings) each have their own electric motor the number of spindles that can be put into a given mill is reduced by the space occupied by the motor if placed as usual at the frame end. This alone will represent probably 4 per cent. of output. Be it understood that the author specifically confines these remarks to cotton mills, the conditions for which are so utterly different from those of a shipyard, for example, which must have boilers for steam heating, engineers, firemen, and so on. The author sees at present no commercial advantage in electric driving; his ear perceives no steadier turning as evidenced by the incontrovertible "note" or hum; his eye finds no evidence in reduced ballooning at the rings. Where, then, does the complication justify itself? Lancashire men consider that if current can be purchased from an outside supply station at 1 farthing per unit it may then pay commercially to adopt electric driving. It now remains for the power stations to say if they can make a reasonable profit when supplying current at the price of 0.25 pence per unit. Can this be done? In considering this question there are many factors to be included, not least of which is the need for steam to warm the mill. Even if electrical energy be purchased from some external source there must still be two boilers installed for heating purposes and a chimney, and labour must be employed to look after these things. If, therefore, electrical driving is to become usual it will be found necessary, in all probability, to generate it at the mill itself or at some central power station within such an easy distance of a group of mills that steam heat can be sent round to each factory from the power station. The heating problem was solved for the Acme Mill at Pendlebury by taking steam from the next-door mill. But this is so particular a case that it cannot be made of general application and rather points against than for electrical driving from an outside source.

Given current at a cheap rate, electrical driving should show many advantages. It would dispense with the rope race and the obstruction this causes in some mills. Lighter shafting could be employed if shafting were still retained, a long shaft having two or more motors in its length. If the large capital interests of the country could find the way to work together for the common interest of all, electrical driving from an outside source could be made a certain success if it was generated by gas engines using the gas from blast furnaces which is at present employed so uneconomically as to be only described as wasted. In England the blast furnaces should stand in the same light as the water powers of Italy, Switzerland and Scandinavia stand for those countries, except that these latter are liable to succumb to

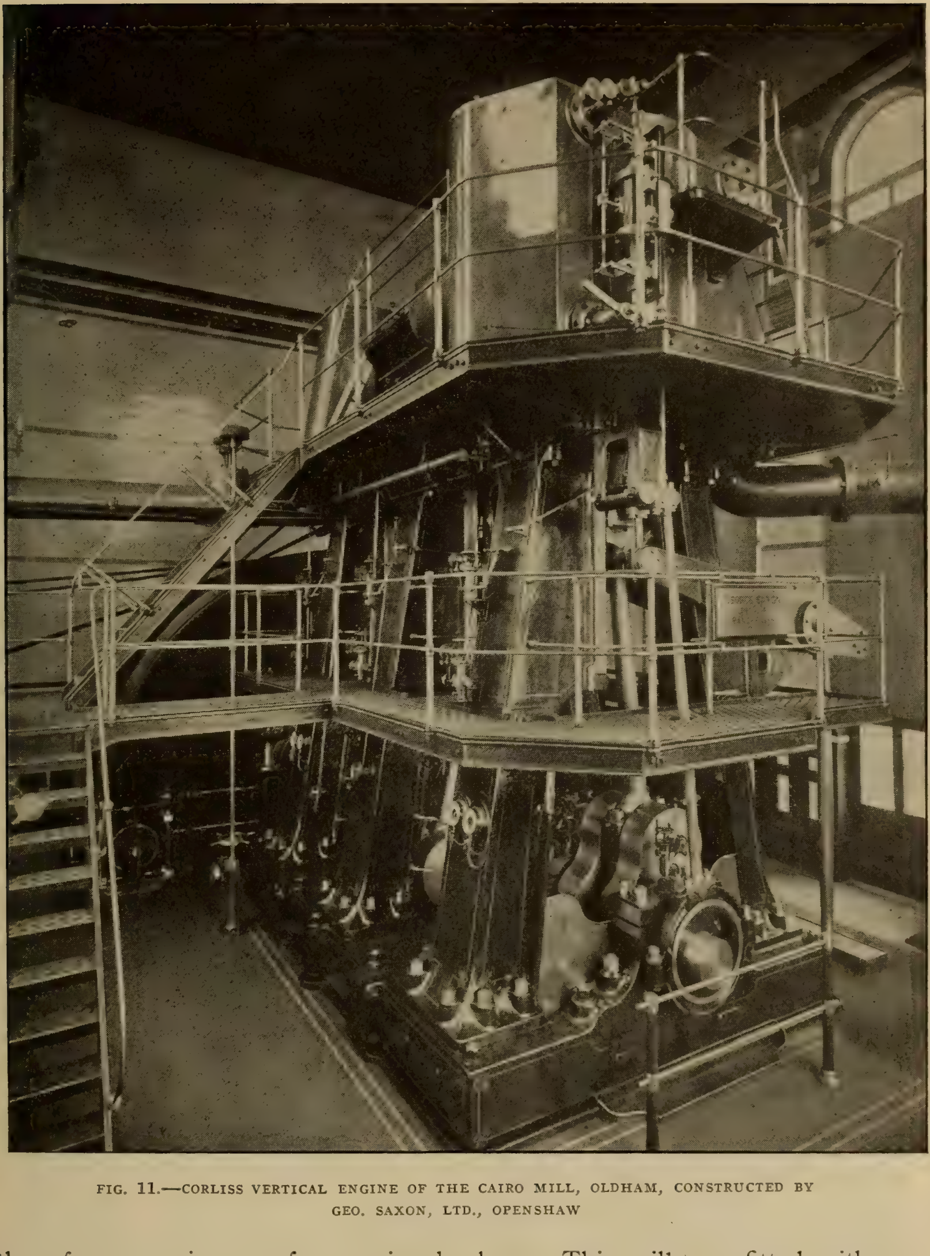


FIG. 11.—CORLISS VERTICAL ENGINE OF THE CAIRO MILL, OLDHAM, CONSTRUCTED BY GEO. SAXON, LTD., OPENSHAW

the *force majeure* of occasional periods of unusually low temperatures.

Though the horizontal is the usual form of engine, some prefer the vertical type because it occupies less floor space. In Fig. 10 is shown the triple-expansion engine like that of the Malta mill at Chadderton, near Oldham. This mill was fitted with machinery by Platt Brothers, Ltd., of Oldham, and with engines by Buckley & Taylor, of Oldham. They are of the inverted vertical triple-expansion type, designed to drive 1,200 indicated horse-power with a boiler pressure of 180 pounds, three cranks at 120 degrees and a rope pulley carried on an extension of the crank-shaft.

The high-pressure cylinder is 20 inches diameter, the second cylinder is 32 inches and the low-pressure cylinder 52 inches. The stroke is 4 feet, the speed 70 revolutions per minute. The valves are of Corliss type and the cylinders are fixed upon a box girder entablature carried by the six standards which are bolted to the main bed. This is 2 feet deep with planed joints and carries within it the main shaft bearings. The various moving parts are of Siemens-Martin steel, the crank-shaft and pin 13 inches diameter and the crank webs 9½ inches thick. The rope pulley shaft is 14 inches diameter in the bearings, which are 35 inches long and carry the 22-foot rope rim, are grooved for thirty 1⅝-inch ropes. The pulley weighs 40 tons. The condensers are placed below the floor and are of jet type, with 36-inch single-acting air pump drain, marine fashion, from the low-pressure cross-head by lever and links. Its stroke is 16 inches.

There is the usual barring engine and rotary pump for oil circulation. In the course of two years or so the same makers built seventeen such vertical engines, averaging 1,200 horse-power, mostly for spinning mills, as well as many horizontal engines. Three boilers of 30 feet by 8 inches diameter, one being spare, will supply steam for these engines, the feed water being heated by a Green's economizer of about 120 pipes per boiler, or, say, 240 pipes. As regards the horse-power necessary to be provided, this depends upon the counts spun and the class of spinning frames.

Coarse counts, such as 10's, require about 1 indicated horse-power for each 45 mule spindles or each 33 ring spindles. This, of course, includes

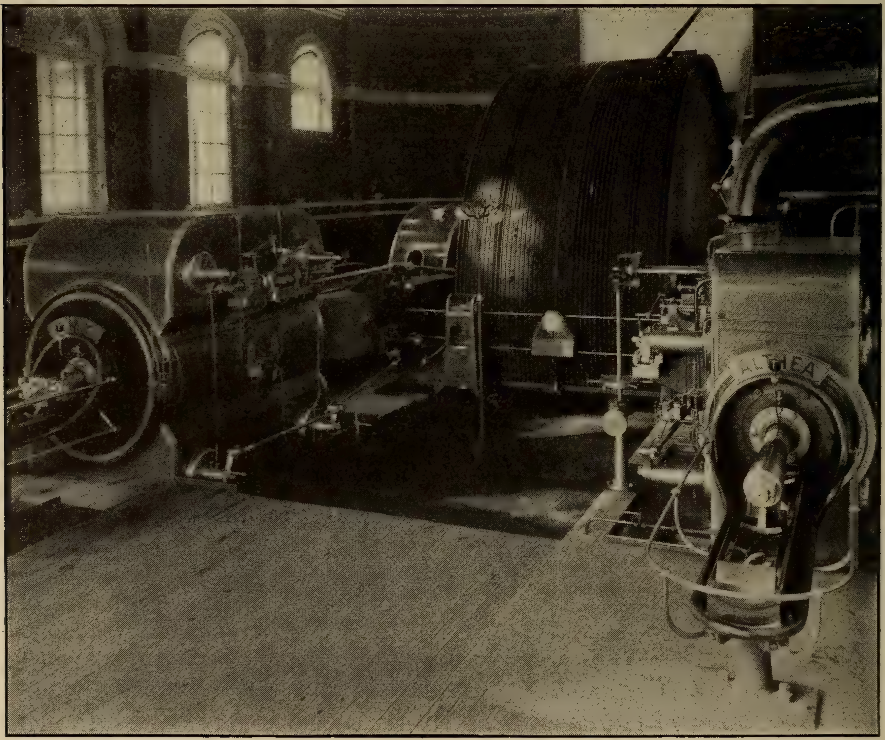


FIG. 12.—ENGINES OF STANHILL MILL. BY YATES & THOM, BLACKBURN

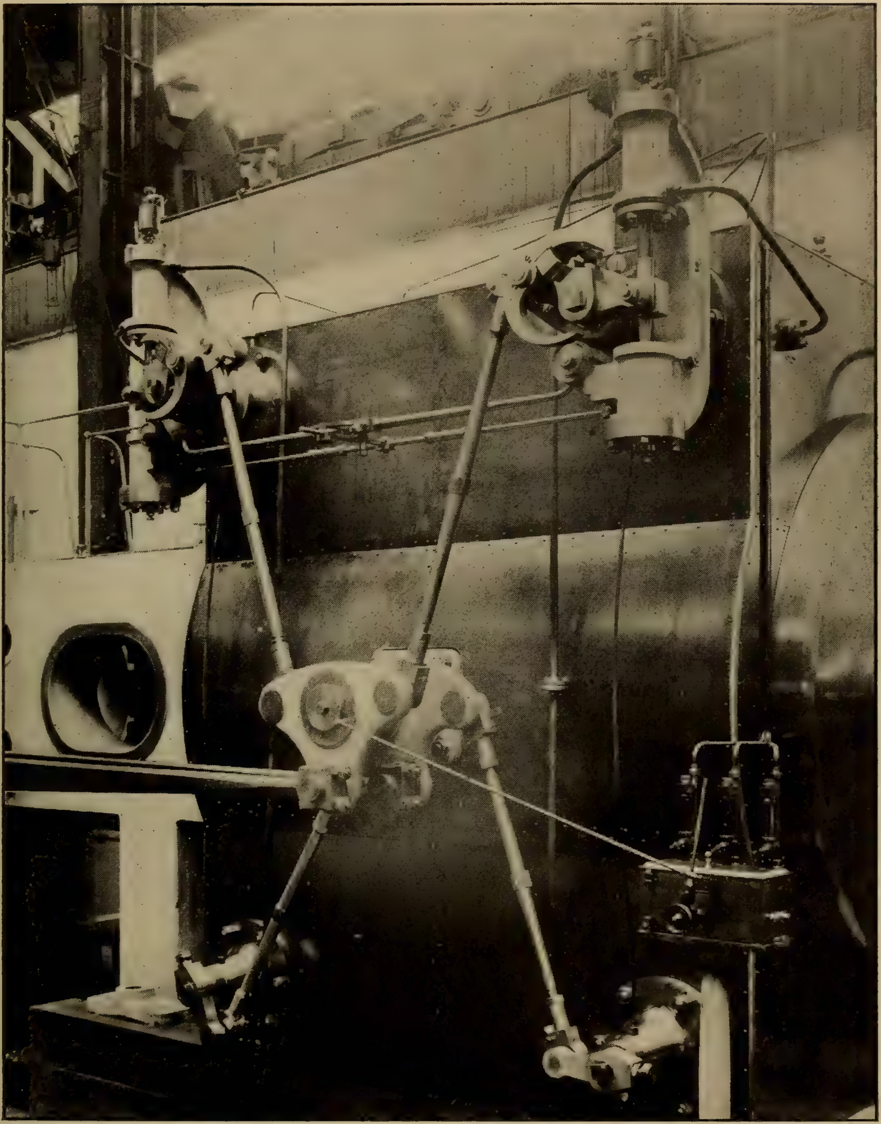


FIG. 13.—SPECIAL STEAM DASHPOT GEAR FOR VARIABLE LOADS. HICK, HARGREAVES & CO., LTD., BOLTON

for all the machinery to be driven. For five counts the number of mule spindles may be 70 per indicated horse-power for 136's and 54 for ring spindles on 50's or 60's. Generally, for equal counts the power to drive a given number of ring spindles, and preparation will exceed by 20 per cent. that necessary for an equal number of mule spindles, partly because mules require less driving than ring frames and partly because the ring frame has a larger support for spindle and requires more preparatory machinery.

Whatever the size of a factory it is equally important in all that the turning effort should be steady, and the modern tendency in some cases has been in the direction of higher speeds of rotation and of the use of three-crank engines. The tripe-expansion engine has lent itself to the three-crank type, but otherwise there is no economy in the triple engine in comparison with the compound engine—no actual overall commercial economy. If the turning is not steady the thread between the front roller and the traveler of the ring frame is caused to balloon outwards, and if not checked by an anti-balloon bracket between each spindle the threads may touch, and bad work is produced. Advocates of electrical driving claim that steadier turning is given by it than by a mechanical rope drive.

The engines (Fig. 11) of the Cairo Mill at Oldham were constructed by Messrs. George Saxon, Ltd., of Manchester. Like those of the Malta Mill they are of the inverted vertical triple-expansion type, with cylinders 18½ inches, 29 inches and 47 inches diameter and a stroke of 4 feet. Each cylinder has Corliss valves and trip gear, that of the high-pressure cylinder being controlled from the governor, while those of the other two cylinders are adjustable by hand. The speed of the engine is 75 revolutions per minute and the boiler pressure is 180 pounds, from Lancashire boilers. Metallic packing is provided for the piston rods and valve spindles. The crankshaft is built up, and has a flanged connection to the pulley shaft. The diameter is 13 inches. The rope pulley has a diameter of 22 feet, so that the rope speed is nearly 5,200 feet per minute, and it is grooved for 25 ropes of 1⅝-inch diameter, and there is a toothed rack and double-cylinder barring engine, the pinion of which is automatically thrown out of gear when the main engine commences to drive the fly pulley. The air pump is driven marine fashion by lever and links from the low-pressure crosshead. It is vertical, 36 inches diameter and fitted with bucket and delivery valves of multiple type with sight soles and inspection doors. The pump is below the floor level. Lubrication to the shaft bearings is effected by positive-feed lubricators and semi-solid grease. The engine cylinders are lubricated by positive sight-feed lubricators, and they have also flush cups. The engine is finished in planished steel. From the floor to the cylinder stage is 16 feet 1½ inches and from the centre crank it is 6 feet 3 inches to each outer crank, the high-pressure cylinder being placed nearest to the fly rim. The wheel swell of the pulley shaft is 16½ diameter and the shaft is about 6 feet between the inner edges of its bearings. There is a certain advantage in this type of engine and fly rim arrangement, in the fact that the engine shaft is separate from the wheel shaft, carries no weight and is designed solely for torsion, while the fly rim shaft is a separate piece and is made a minimum length between bearings, thus enabling it to be kept smaller in diameter.

Fig. 12 is from a photograph of the engines of the Stanhill Mill at Oswaldtwistle. With an indicated horse-power of 1,700 for 70,384 ring spindles and a boiler pressure of 160 pounds there are two horizontal cylinders 30 and 60 inches diameter with a 5-foot stroke, and the speed is 66 revolutions per minute. The piston rods are 7¼ inches diameter, the crosshead journals 8 inches diameter by 10 inches long and the crank pins 11 inches by 13 inches. The crankshaft bearings measure 18 inches by 32 inches, with a wheel swell of 22½ inches and a 24-foot fly rim, grooved for 44 ropes 1¾ inches diameter. This wheel is in reality two wheels, with two bosses and a double set of arms, and rims in segments.

The air pump is made in duplicate with two side by side single-acting 31-inch buckets, the stroke of which is 17 inches, and they are worked by an L lever from the back slipper crosshead of the low-pressure cylinder. This type of compound horizontal engine is, on the whole, probably the favourite, and is made also by the same firms who also build triple-expansion engines.

To return for a moment to Figs. 7 and 8, showing the steam dashpot gear of the Hick, Hargreaves & Co. engine, Corliss valves have been usually closed by steam, by vacuum or by spring "pots." Now the resistance to movement of a Corliss valve is variable and depends on the difference of pressures on either side of its rubbing face. In a factory where the idle load amounts to 20 per cent. of the full working load the pressure of steam is fairly constant during admission, and plain dashpots will do the work with satisfaction and regularity, though sometimes they may need a little help by throttling the steam at the stop valve during minimum load periods. But if called on to deal with fluctuating load of electric generation, which sometimes may vary from mere friction to an overload of 50 per cent., such plain dashpots will not meet the case, for the small steam pressure in the cylinder is too far removed from the steam chest pressure and the valves under this unbalanced loading may fail to close. Hence the use of Hick, Hargreaves & Co.'s special dashpots of Figs. 13, 7 and 8, which overcomes the difficulty automatically.

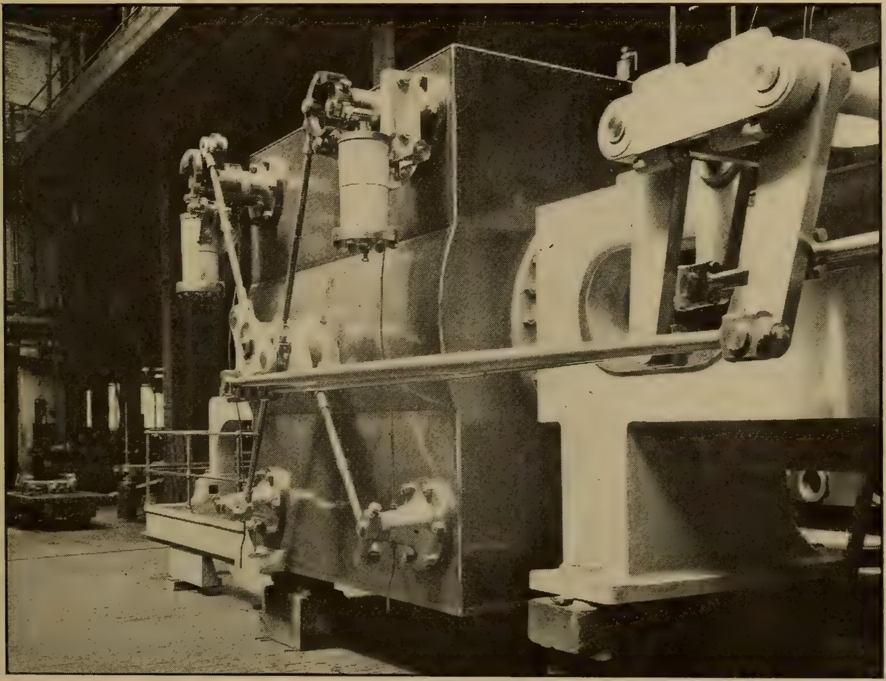


FIG. 14.—ENLARGED VIEW OF CORLISS GEAR. HICK, HARGREAVES & CO., LTD., BOLTON

The dashpot has an upper steam cylinder and a lower air cushion cylinder in one casting attached to the valve bonnet. In the steam cylinder is a plain piston exposed on its upper side to the steam chest and on its underside to the cylinder pressure. The piston rod of this cylinder is larger than needed for strength, its area acted on by the differential of the pressures being sufficient to overcome inertia and friction of the parts, while the variable and larger part of the load comes under the charge of the remaining annular area of the piston.

Thus the steam cylinder is proportioned to close the valve under its maximum frictional load and the air cylinder absorbs the surplus momentum, having under it a fine-adjustment air valve. These special dashpots are applied to the Frickart type of gear, in which the trip is actuated by a separate eccentric which will trip the valve on the return stroke, which ordinary trip gears will not do.

All modern cotton mill engines have safety trip gears which automatically close a stop valve when the governor falls near to its lowest or rises near to its highest position, thus protecting the engine from the danger of a runaway, and stopping it if it runs too slowly, when it would produce bad work.

The engines illustrated in Figs. 7 and 8 have cylinders 36 inches and 78 inches diameter and a stroke of 6 feet. They work with a boiler pressure of 180 pounds and their full economical load is 3,750 indicated horse-power with a 30 per cent. overload margin. They have rope rims of 30 feet grooved for 64 ropes of 1¾ diameter and the wheel weighs 129 tons. The air pumps draw from jet condensers and are of double-acting displacement type. The mill driven by these engines contains 103,000 spindles and 2,000 looms.

# EFFICIENCY IN ITS RELATION TO THE CONSUMER

By H. F. Stimpson

EFFICIENCY is the topic of the day. Few, however, comprehend what its meaning is, who the persons are whose capacity in this respect is susceptible of development or what its development means to that most important person, the consumer.

Efficiency, as a noun, is the relation between the action which has actually produced a known result and the action which would have produced a result which had been determined upon in advance of the performance of the action. It may be qualified by an accompanying adjective, as high or low, or expressed in the form of a percentage. In the current articles it is generally alluded to as being a characteristic which is the peculiar property of manual or mechanical workers and which, as such, should be developed by the direct contact of certain specialists with such workers. Not so. Efficiency is a characteristic common to every person, animal, machine or substance capable of developing or resisting energy. The efficiency of the manual worker should be developed by his immediate line superior. The efficiency of the line superior, in his turn, should have been previously developed by his superior, and so on up the ladder until the chief executive is reached. This is a point at which the specialist properly comes into direct contact with the organization. The time at which this contact should be made is in advance of or simultaneous with the operation of the organization, and not subsequent thereto.

The logic of this is at once apparent. The employment of specialists is simply a method of expanding the brain of the executive. The volume of ascertained fact is now so great that it is physically and mentally impossible for any man, in the time usually allotted to him, to investigate thoroughly and pass upon the details of all the matters which require his decision. As, however, he must issue all directions for action, either personally or by deputy, it is necessary that all information should focus in him or in his immediate vicinity. This can be accomplished only by the assistance of the proper specialists, acting in a purely advisory and personal capacity, who not only investigate for the executive and formulate the technical portions of the decisions he wishes to make and the directions he desires to give, but supplement these directions with such detailed explanations as may be required by the administrators or workers. It is only, therefore, when the efficiency of the executive has been thus developed and supplemented, so that he is enabled to correctly organize his forces, that the efficiency of the forces themselves can be developed.

The development of the efficiency of one or even many organizations, however, is not by any means the ultimate result to be desired. The effect of such efforts upon the community as a whole must be carefully studied. Take a case where the efficiency of the productive workers is made the object of special effort. The immediate result is apt to be a diminution of their numbers, unless the efficiency of the salesmen is so increased as to maintain a sufficient volume of work and the financial department is enabled to supply a correspondingly increased amount of capital. If these conditions are not brought about, the purchasing power of those thrown out of work is decreased and their support is added to the burden already carried with effort by the ones at work. This, in turn, reduces the volume of business, and so a vicious cycle is apt to be initiated. It is perfectly true that the periodic wages of those who continue to work may have been increased by the operation of a bonus system. But while this is a direct gain to such workers, it is offset to some extent by the added burden alluded to above. It is also true that the unit cost of the work to the employer has been decreased, which is a direct benefit to him, yet he also shares in this added burden. But it is still more true that the cost to the consumer has, in all probability, not decreased, and hence no benefit has resulted to him, yet he, too, shares in the added burden. As the consumers constitute a far larger proportion of the entire community than the combined employers and workers in any line of effort, it is clear that the community as a whole has not been benefited. It may even have been harmed because the workers who continue to be employed do not themselves, entirely, maintain those who are displaced. Much of the burden of the support of these latter therefore falls upon that portion of the community which has not received an increase of income from the operation in question.

If, now, we uniformly develop the efficiency of succeeding organizations, we shall continue to increase the number of non-workers, to add somewhat to the incomes of those who remain at work and to the profits of their employers and also to their burden, but to add nothing to the incomes of the workers in plants not so developed while adding to the load they already carry. The purchasing power of the community as a whole, under the present commercial methods, will continue to decrease and a constantly increasing and restrictive pressure will be brought to bear on the volume of trade in general. It would, therefore, seem to appear, because the benefits of the development of efficiency seem to stop short of reaching the ultimate consumer, that such development is injurious and should be discouraged.

The purpose of this article is to endeavor to show that this limitation of the benefits of efficiency is due primarily to an error in the fundamental assumption upon which the whole present scheme of commerce is based, rather than to any defect in the gospel of efficiency. This assumption is that commerce consists in the exchange of certain physical substances known as commodities. This exchange is not usually effected by the direct transfer of the commodities themselves, as in the days of barter, but through the direct or indirect use of a particular commodity known as gold, as a medium of exchange. This, together with its representatives, is commonly termed money. The values of commodities are, at present, arbitrarily fixed by man and are expressed in terms of units of gold, said units possessing certain fixed characteristics as to quantity and quality.

While this view of commerce would seem to necessitate the possession of a quantity of some commodity or of money as a prerequisite to the conduction of commerce, we find, in practice, that the exertion of either mental or physical energy is also accepted, in the place of a commodity, in exchange for money. At the same time both capital and labor deny that the exertion of energy is a commodity. The situation is further complicated not only by the fact that we have no units for measuring mental energy, but that the methods which we have for the use of the units by which we measure physical energy are very crude. The result is that our commercial processes are in an extremely unsatisfactory condition; that there is a constant, annoying and unnecessary strife between the employer and employee, and that the effect on the consumer, be he capitalist or laborer, is detrimental to such an extent that the only reason why he does not violently rebel is his ignorance both of the existence of the fact and of a proper remedy.

Let us, therefore, in considering this most important subject, go back to real fundamentals:

1. The ultimate object of the community is the enjoyment of healthful life. It is not enough that we produce and sustain life. We must have leisure and opportunity to enjoy the act of living and the exercise of our natural faculties, both mental and physical.

2. Life is sustained and made enjoyable by the use of commodities. The commodity, therefore, is subordinate to life. Any factor in the production of a commodity is still more subordinate to the principal end of existence.

3. A commodity is raw material which has been fitted, by the application of energy, to the use and convenience of many. From a consideration of "2" we see that such application is insignificant when compared with the operation of living. Work, therefore, is in no sense to be considered as an end, but only as a means to an end. This end is "life."

4. Energy is of two distinct types:

A. Physical, whose subdivisions are:
  1. Mechanical.
  2. Animal.
  3. Human.

B. Mental, whose subdivisions are:
  1. Human.
  2. Superhuman.

For obvious reasons, allusion will be made at present to human mental energy alone.

5. Mental energy, the peculiar property of mankind, is essential to the proper application of all other kinds of energy controlled or directed by man, whether exerted by machinery, by animals or by his own body. Curiously enough, we know less about it than about almost any other kind of energy.

6. The real value of a commodity to man is, therefore, proportionate to the amount of energy which has been absorbed by the raw material. To determine this absorption we need proper units for the measurement of both types of energy. We have the foot-pound-minute unit or horsepower for measuring physical energy. We have no unit at all for measuring mental energy. All human energy seems to consist simultaneously of both physical and mental types. When the former largely predominates, we speak of the combination as unskilled labour; when both types are more nearly equal we speak of it as skilled labor; when the mental energy predominates, we speak of the combination as an art or a science. This inexact characterization, caused by lack of proper units, makes it extremely difficult to properly adjust the conditions relative to the three different grades of effort. Since the value of a commodity is the amount of energy which it has absorbed, true commerce must consist in the exchange of this rather than in the exchange of the commodities which the energy has produced.

7. Given proper units for the purpose of measurement and taking human physical energy as a basis, we should next determine the relative values, downward, of animal and mechanical energy, and upward, of mental energy.

At present the amount of physical energy, known as a kilowatt-hour, and which can be purchased in large quantities, in the form of electro-mechanical energy, for two cents, would cost about two dollars and twenty-eight cents, if purchased in the form of human physical energy at the rate of twenty cents an hour. In all probability, as will perhaps be deduced from this article, this ratio is not strictly correct. But there is no doubt but that human physical energy can liberate and put into action a far greater amount of energy of the kind which has its terrestrial origin in fuel, in falling water, in wind, or in animals. Hence, measured by human physical energy, such energy is cheaper, just as human physical energy, in its turn, is cheaper than mental energy. Therefore, a correct and exact knowledge of the true ratio of value between the various types is fundamentally necessary for their correct and equitable exchange.

8. To properly conduct what we now realize is the only true commerce it is necessary to establish correct relations between units of all kinds of energy and units of the medium by means of which the exchange is effected. This we have already done to some extent. For instance, in the purchase of coal it is now not at all an uncommon practice to adjust the price according to the number of thermal units contained, rather than according to the weight of the gross substance. While this is a step in the right direction, the ultimate process of exchange will not be correctly consummated until the ratio between the energy contained in the coal and the money paid for it is correctly adjusted to that between the said money and the energy by which the money was earned. Professor Imbert, of the University of Montpellier, France, is reported to have discovered that the price of fifty centimes for cutting one thousand grape-vine shoots of less than six millimetres represented an effort of one hundred ten kilos, whereas the price of sixty centimes for cutting one thousand shoots of a larger diameter represented an effort of two hundred thirty-four kilos. Here was a plain instance of the marked disproportion which undoubtedly permeates our entire commercial system, and is the cause of much of the poverty and distress, whose existence all admit, to say nothing of the continually-increasing disputes between capital and labor. It is absolutely impossible to correct this trouble by increasing the wages of labor. This only adds to the confusion. What is necessary is a revision of our methods of exchanging the application of energy, or, as we continually call it, of labor.

9. It has been found to be both practical and necessary for the protection of the people as a whole, and for the safeguarding of business transactions of every description, that the quantity and quality of the gold in a dollar, which is the basic unit of our present medium of exchange, should be controlled and guaranteed by the government. It would seem to be even more necessary and quite as practicable for the government to eventually guarantee the quantity and quality of energy in a unit of any commodity. Besides the fact that not one producer in ten knows his costs with any degree of accuracy (I speak advisedly) the processes of manufacturing are now so complicated that the unaided judgment of the purchaser no longer affords him adequate protection. Especially is this the case in relation to the practice, now commonly understood to exist, of exacting as large a percentage of profit (or inflation of energy) as "the traffic will bear." While this is generally looked upon with approbation, it is simply because it is not commonly realized that it is only when the number of those to whom a man sells exceeds the number of those from whom he buys that he can permanently prosper under this method. In other words, in the majority of cases, the energy which a worker exerts in order to earn a dollar is by no means equaled by that which he receives when he spends the dollar. If, as we have seen, true commerce is the exchange of energy, the process as at present conducted is most absurdly inequitable. Suppose a day's exertion of human physical energy to be worth one dollar. Consider a man who, working at 90 per cent. efficiency, still receives a dollar. The man then undertakes to spend the dollar in buying a commodity produced by five men working in sequence and at 90 per

cent. efficiency in each case. We shall find that 90% × 90% × 90% × 90% × 90% equals 60%. In other words, the man has to exert his energy for one and one-half days to get the *equal* of the energy which he actually exerted in the first day.

If, as is frequently now the case, the rate of efficiency is far lower than 90 per cent., if the number of concerns that, in sequence, produce any commodity is far in excess of five, and if, also, each of such concerns, by taking an unearned increment of profit, misrepresents the amount of energy which it has contributed to the final result, the condition of the consumer will be indeed pitiable, as is actually the case at present. It is absolutely impossible for the great majority of persons to "hold out" on the few to whom they sell, as much as can and will be "held out" on them by the greater number contained in the long sequence between the raw material and the finished product which the consumer buys.

From the above it may be seen that the imperfections of our present commercial methods, using the word in the broadest sense, are the source of poverty or the so-called unequal distribution of wealth, together with all the evils which follow in its train, and also, as the error is not principally in the relations between capital and labor, that an increase in wages is not the principal remedy. We must begin by recognizing the fact that energy differs in its value to society according to type or subdivision of type, rather than according to the varieties of the same type or subdivision. All types of human physical energy, for instance, should in themselves be considered as equally valuable. When, however, one variety of human physical energy requires a greater amount of mental energy than another in the direction of its application it is not only the additional quantity of energy but its superior type that increases the value of the service rendered to the community which receives the service.

The following constructive meas- first steps in an effort to improve the present unbearable conditions:

1. The determination of a suitable unit for measuring mental energy.

2. The determination of the rate at which both mental and physical energy can be generated by normal individuals, existing under normal conditions, upon normal rations, and still keep within the elastic limits of the individual.

3. The determination of proper coefficients to allow for age and other variations in individuals.

4. The determination of the relative values of the different types of energy, including their subdivisions, taking human physical energy as the basis.

5. The determination of methods by which the government, beginning with the raw material of the principal life-sustaining commodities, may control and guarantee the normal quantity and quality of energy absorbed by every such commodity. This is not exactly a dream. The Regal Shoe Company state that their shoes are sold for an advance of but 5 per cent. on the cost of production. If the government certified that the cost was normal and if the purchaser knew the true value of the energy which he had expended to earn his money, the conditions would closely approximate my ideal.

It is believed that this paper approaches this most important subject from an entirely new angle; namely, the separate consideration of the values created by the application to raw material of mental energy and of physical energy. It is not until we become able correctly to determine the amounts and relative values of the efforts of our brains and of our bodies that we can rationally conduct the process of exchange of these efforts. When that has become possible, and not before, the benefit of the development of efficiency will be equitably distributed over the entire community, as should be the case.

# BALANCING THE ROTORS OF TURBO-GENERATORS

By J. W. Rogers

IT will be generally admitted that the question of balancing the rotating parts of turbo-generators is of the greatest importance, owing to the enormous centrifugal forces they have to withstand; also, the high peripheral velocities obtainable with this type of machinery. For these reasons, it is the custom in modern practice to submit high-speed rotors to a series of exhaustive balancing tests and "overspeed" trials to ensure absence of defects in manufacture and assembling and permanently good balance.

The balancing test of a high-speed rotor is generally carried out in two distinct operations, to determine, firstly, static balance, and, secondly, dynamic balance, it being almost unnecessary to state that good dynamic balance depends upon a good static balance.

The operation of balancing a rotor should extend throughout the period of its manufacture, more especially in the case of rotors for high-speed machines.

In the first place, the shaft, which is forged from the best quality steel, should be of sufficiently strong construction to withstand all strains without deflection, and there should be a complete absence of "whipping" at high speeds, as a stiff shaft is the primary condition for the smooth running of a machine up to its normal speed.

The rotor spider should be well balanced statically before the core plates are fired, each batch of plates being balanced before and after assembling, and when the core and windings are complete the rotor should again be statically balanced.

## STATIC BALANCING

The object of this operation is to obtain equilibrium of the gravitating forces which tend to rotate the rotor about its axis. For this purpose the rotor is placed on case-hardened steel knife-edges, which should have a perfectly smooth surface and be absolutely level in all directions.

The circumference of the rotor at each end is then accurately marked off into a number of equal divisions, one of these marks being placed on the same level as the centre of the shaft. The rotor is then made to roll along the knife edges by suspending a weight at this mark, and the distance traveled is measured. This operation should be repeated for each of the other divisions, and if the distance traveled is the same in each case the rotor may be considered as statically balanced. On the other hand, if the travel varies with the different positions of the rotor, it is necessary to adjust the balance by adding weights, the effect of which is to increase the short and decrease the long travel.

Another method of obtaining static balance consists in causing the rotor to roll a short distance, and when it comes to rest its position is marked vertically underneath. This operation is repeated several times to find out whether the marked portion comes to the bottom on each occasion. Should the rotor come to rest in any position, it may be considered sufficiently well balanced, "statically," for all practical purposes. When the marked portion comes to the bottom on each occasion it is the heaviest portion of the rotor.

It is then necessary to turn the rotor

round until the heavy portion is on a horizontal plane and find out what weight $W_1$ on the opposite end of the diameter is necessary to balance or just set it in motion.

For the purpose of counteracting any errors in leveling up the knife edges, it is advisable to reverse the position of the rotor, so that its heaviest portion is turned round through 180 degrees, the weight required to balance it in this position being, say, $W_2$.

The required out-of-balance weight to be put in will then be given by $\frac{W_1 + W_2}{2}$, which should enable the rotor to remain stationary in any position. Although a rotor may be in perfect static balance on the knife edges, it does not follow that it will also be in dynamic or running balance. When the axial length of a rotor is small in comparison with its diameter, it is quite possible that the static balancing test would prove sufficient for slow-speed machines. In the case of a rotor having a large mass at one end in static balance with an equally large mass at the other end, however, this would set up a couple on the shaft, which would result in considerable vibration when the rotor was revolving at high speeds, a perfect dynamic balance being only possible when the rotor is statically balanced in every plane at right angles to its axis.

### DYNAMIC BALANCING.

For this test the rotor is lined up in well lubricated bearings and fitted up for belt driving by means of a variable speed motor. Special attention should be given to the coupling arrangement, as it is liable to give a faulty indication of the state of balance, the most satisfactory form of coupling being a long shaft of small diameter on which is mounted a pulley of suitable dimensions to give the required speed, as this would be easily deflected by the rotor shaft. The rotor is run up to a speed as near its normal value as possible, having due regard to the maximum vibration which can be safely allowed. The shaft and rotor body are then carefully marked with colored pencil at each end, preferably at the vertical diameter, to counteract the effects of vibration in the bearings. With reference to Fig. 1, let *A B C D* represent the rotor body and *X Y* its shaft. Now, although the points *A C* would be diametrically opposite when the rotor is stationary, the mass would have a tendency to revolve about the axis *E F* at low speeds and axis *G H* at high speeds. After the rotor has been run up to speed and marked with pencil, as described above, it is brought to rest, and if the pencil marks are found to be thickest at, say, point *P*, this indicates that the centre line of the rotor shaft lies along the plane *K O*, instead of being in the normal position *R T*. The balancing weight *W* would fall about point *V* in the plane *V L* with a low-speed rotor, but at very high speeds it would fall about point *L* in the same plane. The angle $\theta$ is determined by the weight of the mass and the speed, and in practice

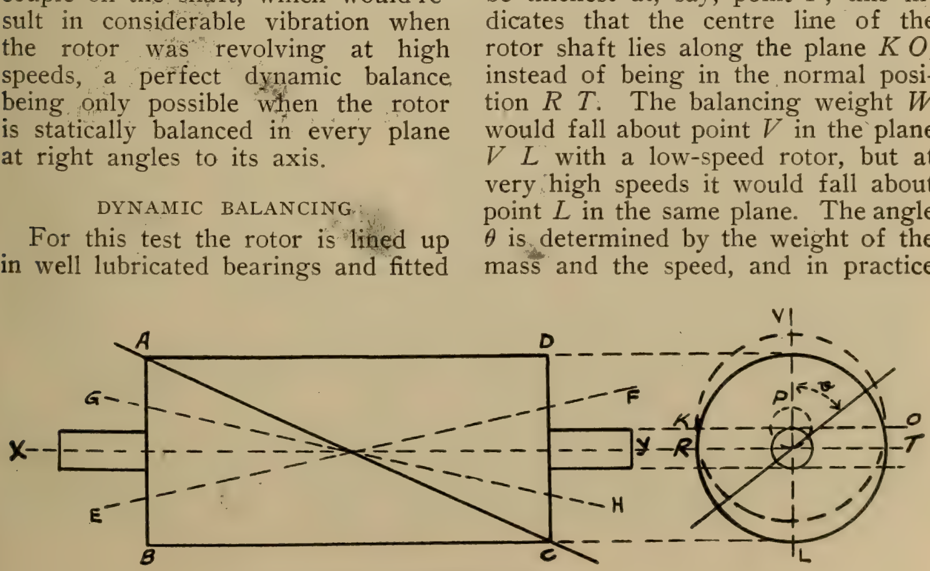


FIG. 1.—DYNAMIC BALANCING.

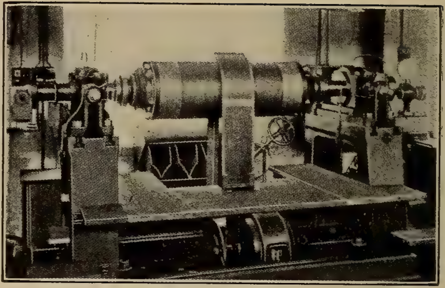


FIG. 2.—BALANCING A ROTOR.

is within 90 degrees under ordinary conditions. If the directon of rotation is reversed and the rotor run up to the same speed and marked, the mean position for fixing the balancing weight may be easily found. A more elaborate method of balancing consists in mounting the rotor on ball bearings, which are free to move horizontally at right angles to the axis of rotation, such movements being damped by powerful springs. The exact method of mounting these bearings is not of vital importance, but they should be securely bolted down and arranged to allow of free movement. Any vibration set up by the rotor when running is magnified to a considerable extent by finely adjusted pointers, the balancing weights being adjusted till the pointers at both ends of the rotor remain in a steady position. The operation of balancing with these indicating pointers is carried out in the following manner:

The rotor is run up to the required speed and the bearing at one end made rigid by adjusting its springs. The springs at the end to be tested are then adjusted to permit of a fairly large horizontal movement, set up by the rotor being out of balance, the number of oscillations depending upon the speed and the degree the rotor is out of balance. The indicating pointer at the end to be tested is now gradually moved forward until the shaft is just marked. This mark will extend only partly round the shaft, and its centre must be fixed as accurately as possible, as it represents the point at which the balance weight must be fixed. Before fixing this weight, however, it is necessary to go through the same operation at the other end of the shaft, and a comparison of the results obtained at both ends will enable the exact position of the out-of-balance weight to be located with

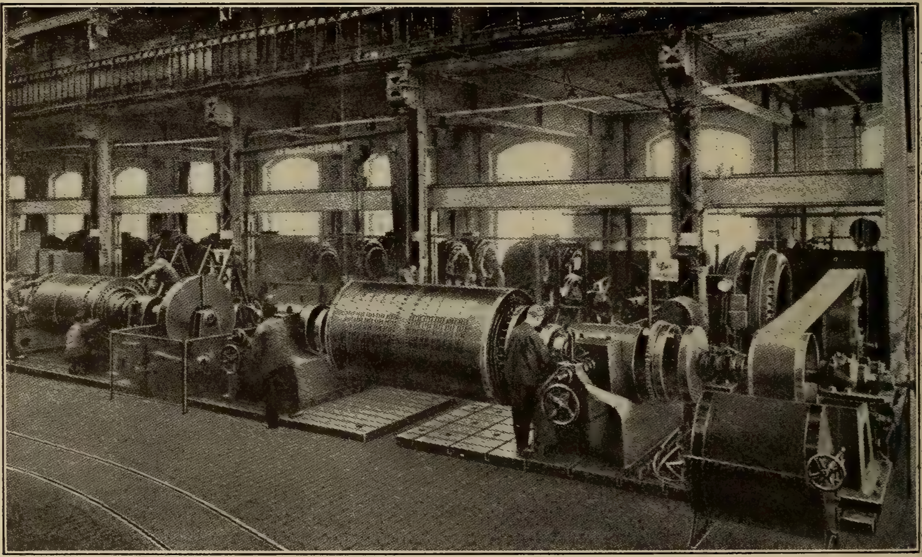


FIG. 3.—ROTOR DEPARTMENT OF THE ALLGEMEINE ELEKTRIZITATS GESELLSCHAFT, BERLIN.

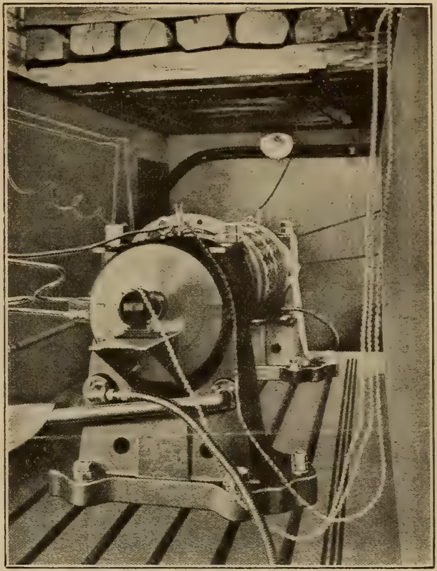
considerable accuracy. When the marks at each end are on opposite sides of the shaft the balance weights should be fixed at each end and opposite sides corresponding with the marking, on the assumption that the amplitude of the oscillations at each end was equal.

On the other hand, assuming the amplitude unequal at each end and the marks on the same side of the shaft at both ends, this should be taken as an indication that an equal weight was required at each end of the shaft.

This method of balancing is illustrated in Fig. 2, which represents the arrangement used by the A. E. G., Berlin, and a very good idea of its extensive application is given by the illustration in Fig. 3, which represents a view of the rotor section in the turbine shops of this company.

With the arrangement shown in Fig. 2, the rotor is mounted on ball bearings, which are controlled by powerful springs, the movements of the bearings, due to the vibrations of the rotor shaft, being indicated on a scale by an arrangement of levers. As the use of such indicating devices can serve only as a guide to show when a rotor is balanced or otherwise, the operation of balancing is purely a matter of trial and error; at the same time, however, it requires a considerable amount of judgment on the part of the operator to obtain satisfactory results, and especially in the case of high-speed rotors. When the balance is adjusted by the addition of weights to the various parts of a rotor, care must be taken to keep them on the same axis, otherwise the static balance would be upset—that is to say, when a weight is put on one end of the shaft an equal weight should be fixed diametrically opposite at its other end; and, if further adjustment is necessary, both of these weights should be moved round the rotor together on the same axis until perfect dynamic balance is attained.

It is sometimes found in practice that the original static balance is upset, due to a slight movement of the windings when the rotor is run up to speed, and in such cases adjustment must be made accordingly by a further addition of weights.


OVER-SPEED TESTING APPARATUS.

With turbine rotors it is generally impossible to obtain accurate static balance, in which case these are submitted to the dynamic balancing test alone.

As regards the position of the balancing weights, this depends to a great extent on the design of a rotor, and in some cases balance may be adjusted to a certain degree by removing portions of metal specially provided for this purpose. The employment of separate weights, however, permits of easier and quicker adjustment, and, provided these are securely fixed, this method is considered more satisfactory. In modern practice it is the custom to fix some suitable arrangement at each end of the rotor for attaching these balance weights, and the most convenient consists of a brass ring having holes drilled and tapped at equal distances round its circumference, in which case the weights would consist of small studs screwed into these holes where required and securely fixed by caulking the heads, this method being generally used for balancing turbine rotors. Another method consists in forming pockets in the casting, which are filled in with lead, but this is only suitable for rotors of low-speed machines.

### OVER-SPEED TRIALS

After the balancing process has been completed, a high-speed rotor is submitted to an over-speed trial, which is carried out in a specially constructed room, an example of which is shown in Fig. 4, which represents one of the testing chambers in the A. E. G. turbine factory. It is of interest to note that all high-speed rotors manufactured by this company are submitted to a 50 per cent. over-speed run, this test being equivalent to a stressing of the various parts by centrifugal force of more than twice the normal.

These over-speed trials may be considered a very severe test of the quality of materials and workmanship, as a rotor is expected to withstand having its balance upset.

In conclusion, the writer's thanks are due to Messrs. The A. E. G. Electric Company, of Cardiff, for information dealing with the testing of their turbine rotors and also the illustrations shown in this article.

# THE WATER SUPPLY OF A GREAT CITY

## II.—OPERATIVE CONDITIONS

By J. F. Springer

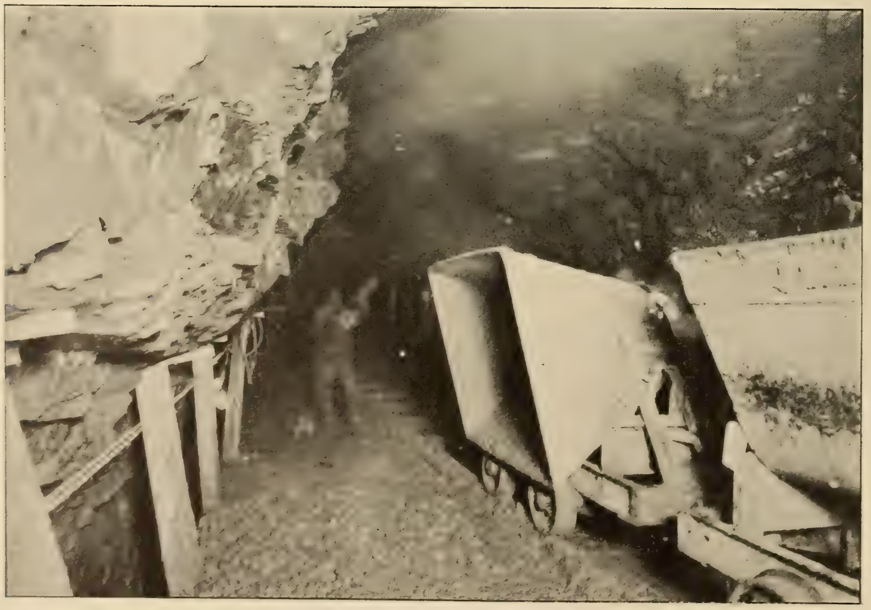
In the July issue of this magazine Mr. Springer discussed the requirements of New York city as regards water supply, and gave some account of the various plans which had been proposed for future demands. The plans for the Catskill aqueduct were described, and a portion of the work already under way illustrated. The present article continues the general description of this great undertaking, and a third and concluding article will be devoted largely to the mechanical equipment, which has made the work practicable.—THE EDITOR.

THE conditions at Peekskill Creek, which led to the adoption of steel pipes instead of a rock tunnel, are interesting. The valley at the crossing is about 320 feet deep. On the north side is Hudson river shale; on the south, buried beneath a thick deposit of glacial sand, is Fordham gneiss; between lie Wappinger limestone and Georgia quartzite. The valley is only about 1½ miles broad, and yet we have here four geologic formations. In fact, all the strata are standing on end. Very extensive investigations were carried out by drilling, especially in the limestone. Some of the holes penetrated depths rising to 390 feet below the surface. The rock profile disclosed no deep gorge, as had been expected. But especially because of the doubtful character of the limestone as disclosed through the drilling operations, the rock siphon idea was abandoned. The shafts at this location would probably have to be very deep. On the whole, the steel pipe following the surface has been preferred.

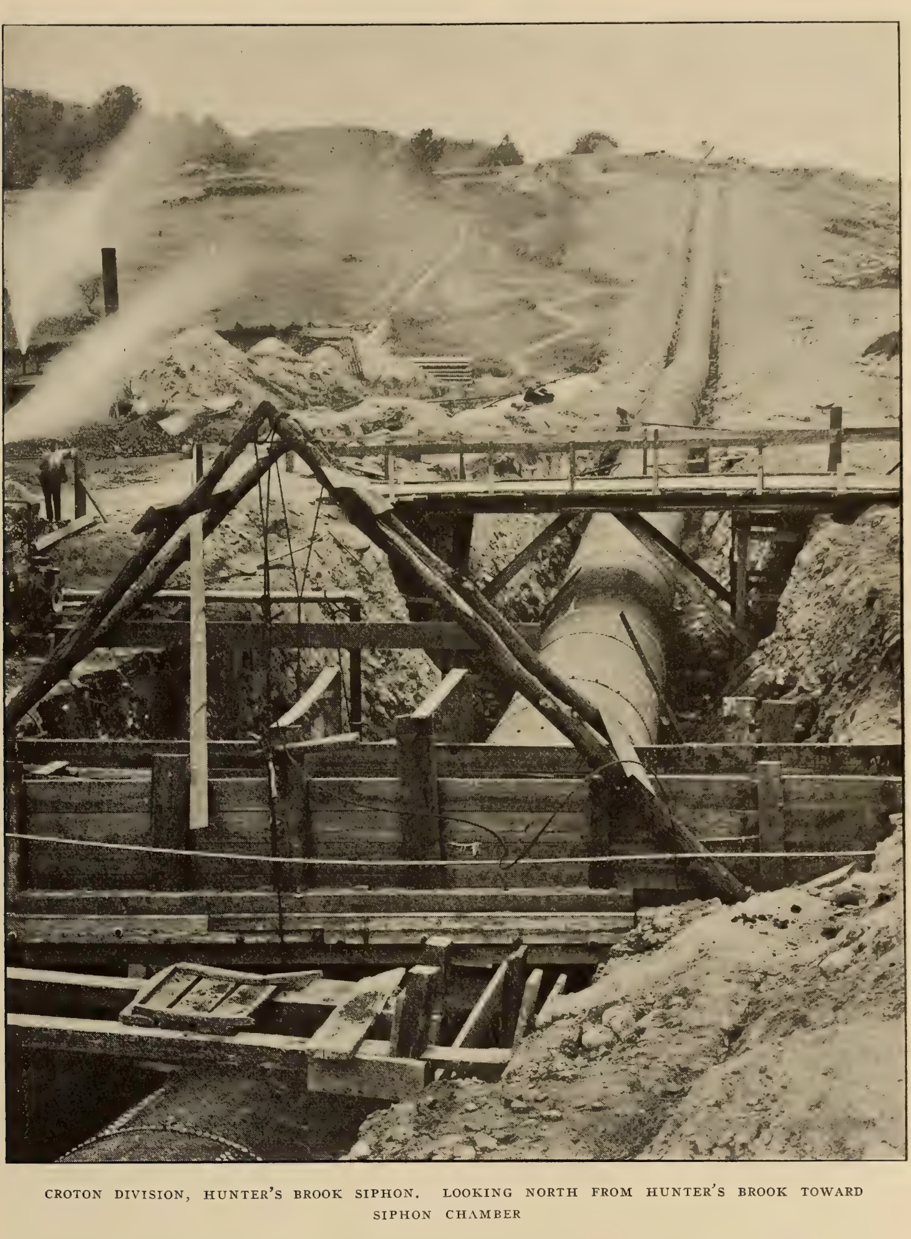
Sub-surface investigations for a work of the character of the Catskill aqueduct are not only advisable, but absolutely necessary, if economy of construction and maintenance are to be considered as prominent factors. This is true, as we have seen, in connection with the sites for dams, but also where rock tunnels are possibilities. The great Ashokan dam is, perhaps, the most striking instance where the question of foundation is the problem. To determine the exact location of the new Kensico dam the bore-hole has been indispensable. This dam is to impound 40,000,000,000 gallons, and will have a height of, perhaps, 250 feet. Eleven hundred feet of the crest will rise to a height exceeding 150 feet. It is readily granted that the foundation must involve no uncertainty.

The great conduit, it will be understood from the account given, will not follow an unbroken straight line by any means. Not only is this the case as to the level, but it is also true of the alignment. The great reason for this is an economic one. By far the cheapest construction is that termed cut-and-cover. In this the aqueduct is nearly or completely buried and the top performs simply the office of a cover. This style of construction is permissible only where the hydraulic pressures are due solely to the weight of water in the conduit in the immediate vicinity. The upward pressure is either *nil* or negligible. Such a conduit is nothing more nor less than an inclosed stream bed. Now, from the fact that the hydraulic gradient has to be followed—in order to eliminate pressures due to head—it results that a good deal of irregularity in alignment has to be introduced. It is almost precisely the same problem as is encountered in locating a railway. And so it comes to pass that here and there the aqueduct will conduct its water locally in a direction leading more or less away from New York City. But, so far as the writer is aware, there are no horseshoe bends.

Just as with railroads, it is often a question of economics whether a deep cut will be made or a tunnel constructed through a hill, or which of some similar pair of alternatives will be selected. For grade-tunnel construction the conditions are ordinarily not severe. It is just about the same problem as the construction of a railway tunnel. There is no question of pressures arising from hydraulic heads. If the hill can be economically pierced there is no difficulty. But with siphon construction the case is far different. Here hydraulic pressures varying with the head are a factor, and, it may be, a controlling one. For considerable maximum heads, say of 125 feet or more, the rock siphon and the steel pipe are usually alternatives. Mr. T. H. Wiggin states that from an economic point of view the matter is of such close equality that it will not be possible to tell whether the pipe would have been cheaper or not than the rock siphon. In the case of the pressure tunnel—as the rock siphon is called—there is a heavy, sometimes an enormous, first cost. Thus, if the downtake and uptake shafts pass through strata heavily watered, we have the expensive construction imposed by this condition. It is a mining proposition; but the material of the whole siphon must be such, or must be made such, as to be able to withstand the head pressures corresponding to the various depths. In some cases the hydraulic gradient of the aqueduct is much higher than the local water level. Thus, there is 400 feet difference at the Hudson River crossing. The question of the soundness of rock becomes highly important, because of internal hydraulic pressures. And as the engineer goes further down to get rock of sufficient soundness to suit pressure conditions he had in mind, the pressures themselves increase. The steel pipe is generally, if not always, cheaper in first cost. When it is an alternative to the pressure tunnel the pipe siphon



ESOPUS DIVISION, RONDOUT SIPHON. VIEW OF PLATFORMS UPON WHICH CONCRETE IS DUMPED FROM CARS, AND SHOVELED BEHIND FORMS

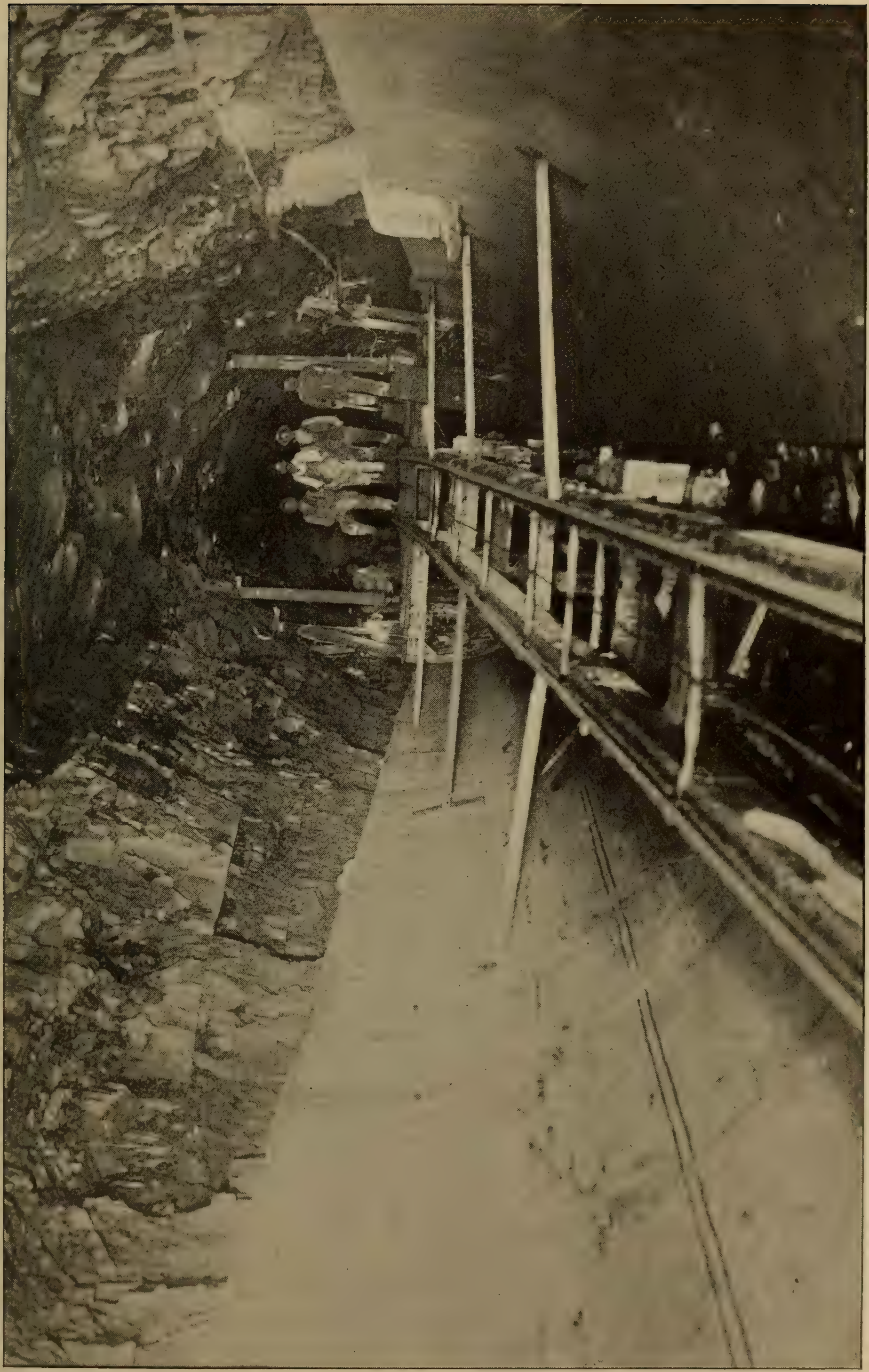


CROTON DIVISION, HUNTER'S BROOK SIPHON. LOOKING NORTH FROM HUNTER'S BROOK TOWARD SIPHON CHAMBER

is laid at or near the ground surface, so that the maximum hydraulic head is simply that due to the lowest level of the valley below the hydraulic gradient of the aqueduct. Further, the steel pipe siphon may be divided up into several siphons of comparatively small diameter. Thus, instead of a single 17-foot pipe, four 8½-foot pipes could be substituted, as having the same carrying capacity, the difference in friction being disregarded. But the rock siphon is permanent construction and involves little or no maintenance. At least this is the expectation. The steel pipe, on the other hand, will need replacement from time to time. Of the total amount of 24.76 miles of siphon occurring between Ashokan reservoir and Hill View reservoir at Yonkers, 6.37 miles are to be of steel pipe and 18.39 of pressure tunnel. The length of pressure tunnel is somewhat larger than if pipe were used, because of the greater depths. The pressure tunnels are six in number, the pipe siphons fourteen. The average lengths are, respectively, 3.065 miles and 0.455 mile. We conclude that the rock siphon is, generally speaking, prepared for the wide valleys, despite its heavy first cost. A consideration that enters here is that deep end shafts are just as large an item in pressure-tunnel construction in narrow valleys as in wide ones. In New York City itself there are to be 17.6 miles of pressure tunnel and 15.9 miles of steel siphon. As illustrative of the large way in which shaft construction controls the choice of construction in narrow valleys, the case of Sprout Brook valley may be cited from Mr. Wiggin. The total length of steel pipe required is 2,260 feet, which is only 30 feet more than the length of the horizontal portion of the pressure tunnel. The length of shaft construction is 1,250 feet, which is a tremendous item to balance against the 30 feet of pipe. This is, perhaps, a rather extreme case. But taking all the valleys into consideration, the pressure tunnel has been selected for no valley as narrow as the average of the pipe valleys.

In constructing the pressure tunnel the engineer has to remember that the structure will have two hydraulic pressures with which to deal. There is the pressure from within outward, due to the level below the hydraulic gradient. With a maximum depth of 1,200 feet below the river surface, which may be necessary at the Hudson crossing, and a hydraulic gradient 400 feet above that surface, there will be the enormous pressure due to a head of 1,600 feet. There is also an external pressure, operating to crush the concrete lining of the tunnel, due to the head of ground water. It might be thought that these could be pitted against each other and that the lining would only have to endure the difference. And perhaps something of this kind could be done if the engineer could select the conditions under which the hydraulic heads are to operate, and, having selected them, could also secure their invariability. One large fact has to be taken into consideration: the tunnel must be constructed with the ground water head unbalanced. Further, this unbalanced condition will actually occur whenever the operation of the aqueduct is suspended for repairs or for any other cause. Normally, however, when once the flow of water has begun, we shall have a pretty constant head. But who will guarantee the constancy of the ground water pressures? And, further, the determination of what this effective pressure, due to the external head, is, for any given location, not so simple as one might imagine. The porosities of both rock and lining are factors which play a large part. The pressure will, of course, never be greater than that due to the weight of a column of water rising to the maximum local hydraulic level. But it may be much less, or even nothing, depending upon the tightness of the rock. And it seems that if the rock is tight and the lining porous, we may expect no pressure on the lining. But the condition of natural tightness is rather unreliable. The rock itself may be tight enough, but the occurrence of a crevice may introduce a tremendous pressure. It is proposed to make the rock tight by artificial means.

It will readily be understood that the conditions of excavation are such as to produce great irregularities in the surface of the tunnel walls. The concrete lining, however, obliterates this condition and produces an interior surface fairly cylindrical. But this concrete lining cannot be depended upon to make a porous rock



ESOPUS DIVISION, RONDOUT SIPHON. VIEW LEADING TO PLATFORM FOR REPLACING CONCRETE BEHIND SIDE WALL FORMS impervious. In fact, it is scarcely possible to fill all the voids absolutely. It is proposed, therefore, to force a cement grout in back of the lining. This will be done by the use of rather high pressures. Short lengths of, say, 50 feet, will be treated as separate units, the flow of grout being confined by suitable means. In the concreting operation the ground water has to be dealt with temporarily, in order to protect the concrete when green.

It has been thought wise to follow the general rule of locating the pressure tunnels at such depths as to insure a covering of 150 feet of sound rock. This may seem an excessive allowance. It must be remembered that the pressures which occur are often very great, and that there is no precedent where conditions are so severe. At the Hudson River crossing it has seemed wise to locate the horizontal tunnels on both sides of the river at a depth of about 200 feet below the surface. The principle governing here is to provide a covering competent to resist by its weight alone the upward pressure exerted by the water in the tunnel. If we take the specific gravity of the overlying mass at 3, we have to find a depth such that, added to 400 feet, a column of water of the total height would equal in weight a similar column of the solid material of a height equal to this depth. We thus get the value of 200 feet for the thickness of covering.

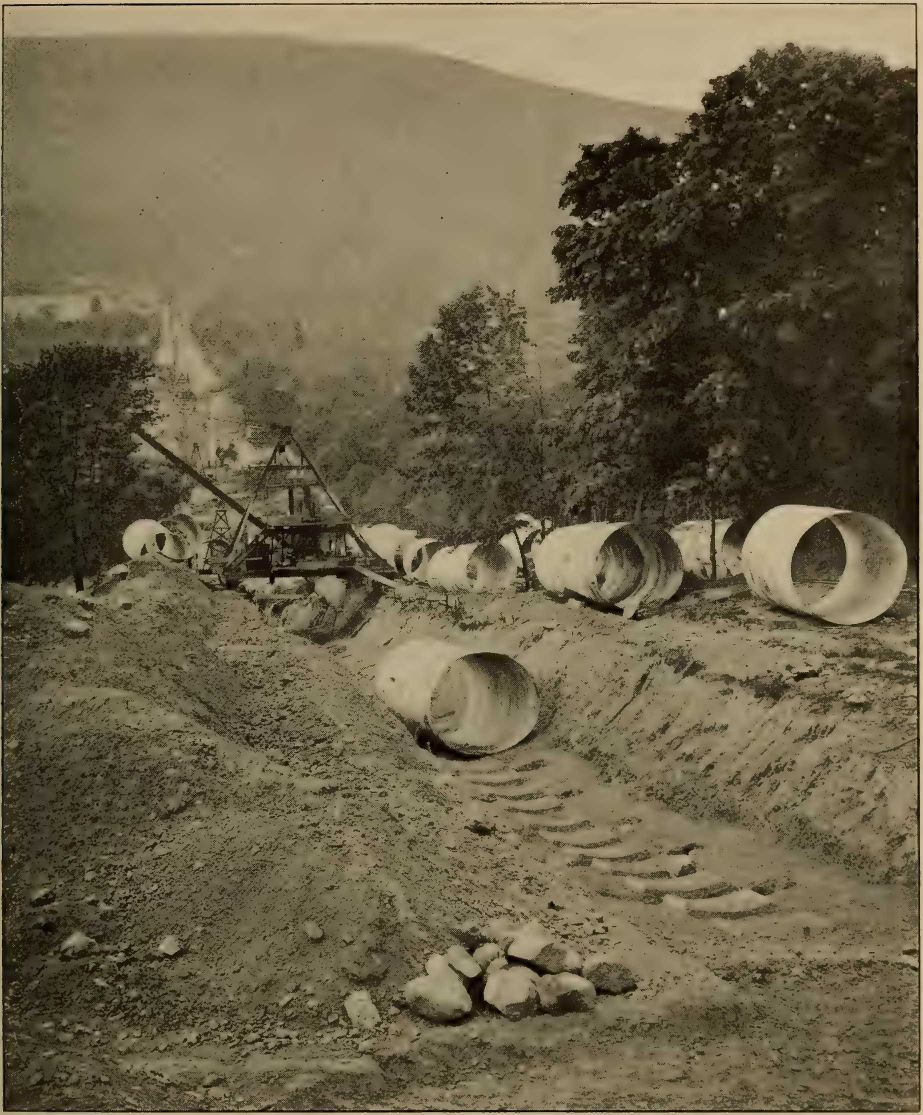
The standard type of pressure tunnel is a finished waterway, circular in cross-section and 14½ feet in diameter. One object of this form is its strength against external pressure. There is thus a clear area of 165 square feet. The concrete lining will, of course, vary greatly in thickness, because of the inequality in excavation. But nowhere around the circuit will it be less than 5 inches.

The vertical shafts at each end of a siphon constitute important elements in its construction. The Rondout siphon crossing a valley 4 or 6 miles in width will have six other vertical shafts. One is to be finished and left for drainage purposes. The other five are to be filled in after they have served their temporary purpose in construction. If it were not for such intermediate shafts the transportation of muck from the headings would be excessive. The great siphon across the Walkill valley likewise requires construction shafts, but not quite so many.

It is scarcely likely that compressed air will be used in the operation of shaft sinking. Its serviceability is terminated at about 100 feet below the water level. The operations usual in mining will be depended on. The permanent shafts forming the legs of the siphon are to be concreted. In cross-section they are to be circular. At the beginning, construction proceeded by using both circular and rectangular cross-sections. It has been found, however, that the circular shaft is more quickly and economically constructed — at least in shale. Excavation at the bottom and concreting the walls go on simultaneously. There is a platform from which the concreting is done. The muck buckets, going up and down, pass through its centre. To prevent injury to the lining, guide ropes held in place by weights are employed in case the lining has to be carried on in the immediate vicinity of the bottom. But little temporary support is used, and the saving due to this is estimated as enough to cover the cost of the concreting.

In joining the permanent shaft to the horizontal section at the bottom a curve is used. This is an expensive form, but is thought to pay well, because it eliminates some of the friction which would otherwise occur at the elbow.

It has seemed desirable to have the heads of permanent shafts in rock. But this has not always been possible. In these cases the heavy siphon or pumping chamber will have to rest



HUDSON RIVER DIVISION, FOUNDRY BROOK SIPHON SHOWING 9½-FOOT STEEL PIPE AND CONCRETE SUPPORTING BLOCKS

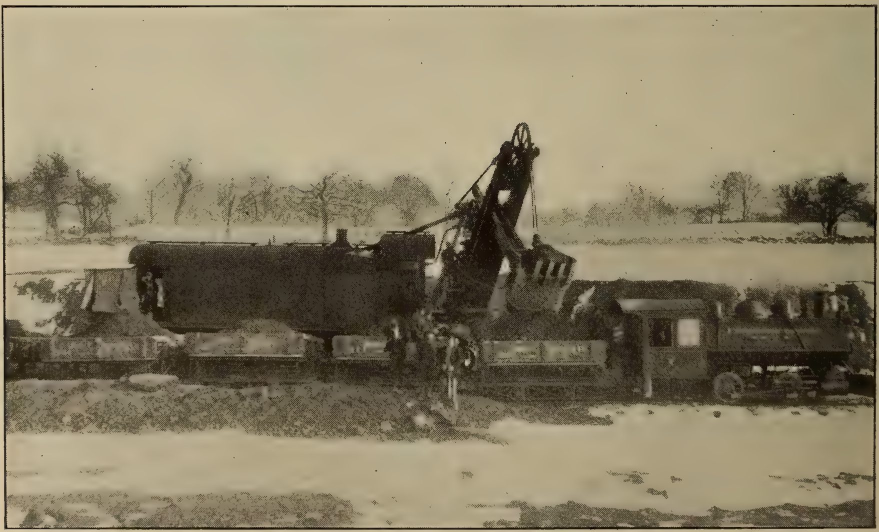
on a different foundation. The idea is to line and grout the earth shaft so as to eliminate settlement. The cross-sections of the construction shafts have been made small, largely because the amount of material to be removed is not great nor the rate rapid. It is estimated that only 7 cubic yards per hour is all that will have to be handled by two cages.

Do the pressure tunnels require drainage? The answer seems doubtful. Some time it may seem desirable to get the water out of the siphon. But no one knows when this need will arise nor what will be the urgency. However, as the need may come, drainage plants are to be provided at a cost of less than $1,000,000.

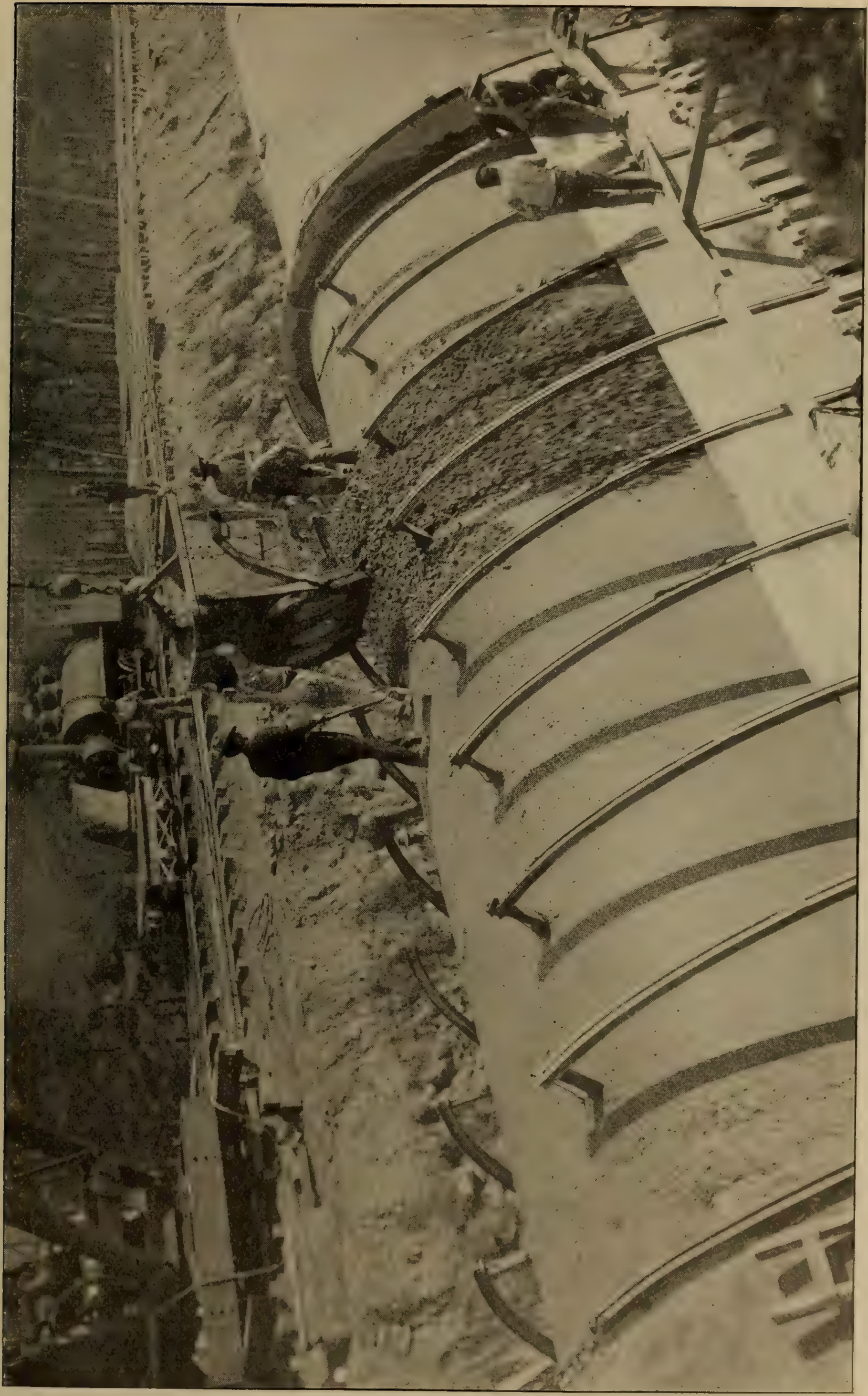
The construction of the steel siphons is much more simple than that of the pressure tunnel. The internal pressures are moderate, and there are no external ones. There are no vertical shafts, nor any considerable excavation. Everything turns on the strength of the pipe itself. As before mentioned, a single large conduit can be replaced by a number of smaller ones. In this way strong resistance to rupture can be provided. The pipes are, of course, circular in section, the clear internal diameter being 9 1/6 feet. They are to be lined with cement mortar, and are to be completely enveloped in concrete. Thus the metal will be protected from corrosion. Just what the life of such construction will be no one knows. There are several factors concerned in the problem. Free oxygen in the water must be excluded from contact with the steel, and atmospheric oxygen must likewise be kept out. The thin lining of cement mortar inside is relied upon in the one case. If the lining can be preserved from cracking, considerable success may be anticipated. Such cracking might arise from differential expansion and contraction of the three layers of concrete, steel and mortar. The coefficient of expansion of concrete and steel are so nearly alike that for moderate changes of temperature but little trouble will be probable, if steel and mortar can be kept at approximately the same temperature. That some difficulty surrounds realization of this requirement will be conceded when one reflects that the mortar is kept at a slowly changing temperature, while from the outside the steel is subjected, to some extent, to the variations of the weather. The mantle of concrete and other material without operates, however, to obliterate sudden temperature fluctuations. Whether this obliteration will be sufficiently complete can, perhaps, not be determined now. On the outside, the concrete covering, if sufficiently dense and of the right chemical constitution, will act as an effective protection, provided it, too, can be kept from cracking. It would seem probable that the life of the steel siphons of the Catskill aqueduct is largely dependent upon the interaction of thermal conditions. It will, of course, be interesting to learn just how the matter comes out.

### DRAINAGE

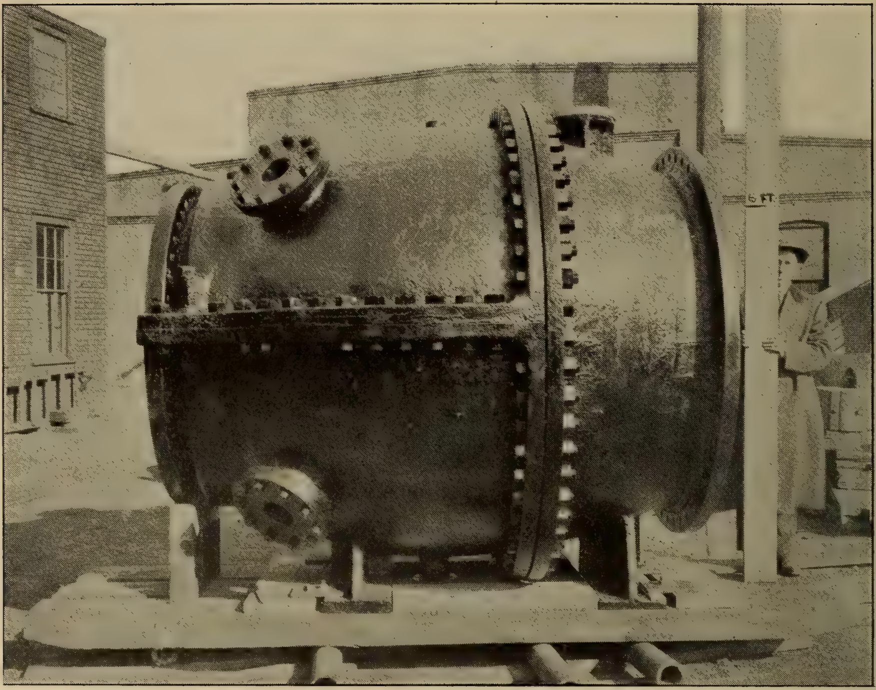
The question of drainage has already been adverted to, but only a



ATLANTIC STEAM SHOVEL. BUILT FOR J. C. RODGERS CO. BY THE AMERICAN LOCOMOTIVE COMPANY, USED FOR CONSTRUCTION WORK ON THE ASHOKAN DAM.



PEEKSKILL DIVISION, METHOD OF DUMPING CONCRETE ON ARCH CENTREING,



A 48-INCH CONTROLLING VALVE

little said. The point at which the greatest difficulty will no doubt present itself is in the vicinity of the Hudson river crossing. At the point where the aqueduct passes below the Moodna creek the gorge of the Hudson lies only a couple of miles away. Here the conduit will make a tremendous drop, so that, even if the topography of the intervening country be such as to afford suitable rock for the tunnel to rise to grade 400 feet above the Hudson, there is no especial advantage in having it do so. It is proposed to carry the tunnel along beneath the Moodna 600 feet below grade to the west bank of the Hudson and there drop down to the level of crossing—which may be 1,000 feet lower yet. It is also proposed to connect the portion on the 600-foot level with the surface of the ground to the west of the Hudson and with the down-take shaft of its siphon. The mouth of this access shaft will be above the river surface. It will be possible to run steel pipe from this shaft to make temporary connection with the aqueduct on the east side if construction on the great siphon should be greatly delayed. On the east end of the siphon the uptake is divided into two sections connected by a short horizontal length. This arrangement permits one-half or more of the uptake to be constructed close to the shore. Now it is proposed to continue this part of the uptake on up to the surface and to construct a removable cover. A similar closure is to be effected on the west side in connection with the access shaft. There the shaft is to be but 8 2/3 feet in diameter, while in the east side the removable cover is for a shaft 14 feet in diameter. If this cover is located at a point 400 feet below grade, then there will be an upward pressure of 173 pounds per square inch. There will thus arise an upward thrust of about 3,800,000 pounds. The cover is to be of cast steel and dome-shaped. Sixty 3½-

OLIVE BRIDGE DIVISION, BEAVER KILL DIKE. AQUEDUCT CUT

inch steel bolts are to hold it in place. It is computed that the bolts will be subjected to a tensile stress of about 9,000 pounds per square inch and the cover to a stress of about 3,000 pounds per square inch. In order to hold this cover down it is necessary, not only to bolt it securely fast to a frame, but to arrange that this frame and attached parts shall supply sufficient resistance. The upward pressure of the water will affect whatever it operates against. This would apply to overlying rock and earth if it were not removed from the influence, so that, if we propose to weight the cover down with such material, it will be necessary to withdraw from it the effects of the head. To do this a steel line is constructed reaching down the shaft for, perhaps, 100 feet, with the object of removing the upward hydraulic pressure from the rock and earth in the immediate vicinity. There would thus be an inverted and perforated truncated cone of material surrounding the shaft and with its weight unbalanced by the water. At a distance of about 60 feet down an anchor ring is arranged and connected with a massive frame by great tie bolts. As the cover is attached to this same frame, the upward thrust of the water will be transmitted to the anchor ring, 60 feet below. This, in turn, will press against the weight of a mass of rock and earth shielded by the lining from the more direct effects of the head. It is estimated that a mass of rock and earth extending for 60 feet above the anchor ring in a shell ever thickening at the rate of 1 foot horizontally to a rise of 2 feet will, if protected from the more direct hydraulic pressure, be sufficient. The anchor rods are 4 inches in diameter and thirty-six in number. To move the great cover, out-board brackets are provided. Small trucks and suitable fixed rails constitute the means of running the cover off to one side when the trucks are placed in position under the brackets. The anchor bolts pass through sleeves in which vaseline is placed. The rods are thus separated from contact with the rock, earth and concrete, so that expansion under load will not disarrange the material surrounding them and protecting from corrosion.

If anything gives way and the water bursts forth, the location is, it is thought, suitable. To effect drainage, the water is permitted to blow off until a certain level is reached, when a pump may be attached and the level still further brought down. To get the water out of the siphon itself pumping will have to be continued. It is proposed to place a single full-capacity blow-off somewhat to the east, but below the grade, or several smaller valves on the drainage shaft itself.

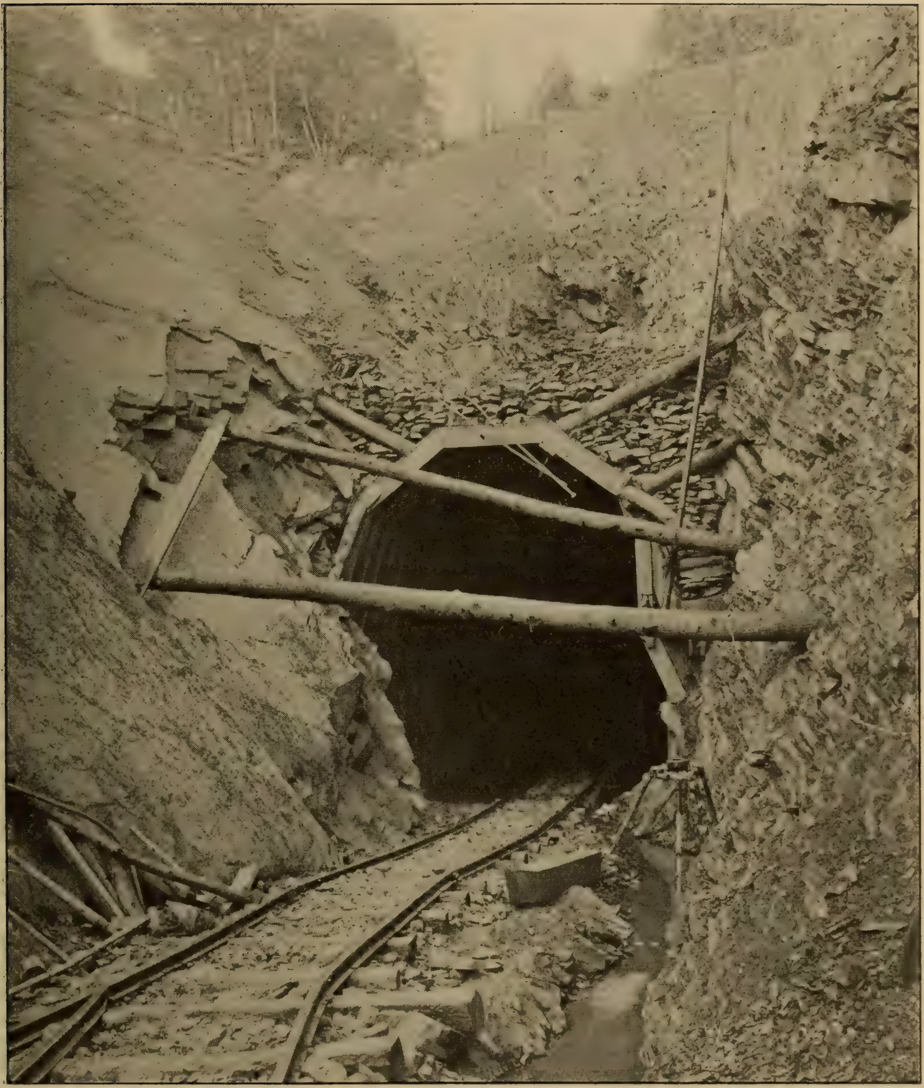
### JUNCTION OF PIPE LINE AND PRESSURE TUNNEL

At many points along the line of the aqueduct piping and tunnel will have to be joined. As there will usually be several parallel pipes, more or less interest attaches to the mode of effecting the juncture. Perhaps the most interesting case is where the triple steel pipe siphon of the Bryn Mawr valley connects with the pressure tunnel of the Yonkers siphon at a point 165 feet below grade. The pressure amounts to about 71 pounds per square inch. The tunnel has a diameter of 16 feet 7 inches. The pipes are carried into its portal a sufficiently generous distance to obviate leakage. Three small tunnels are constructed to receive the pipes. These tunnels unite, further along, to form the single large tunnel. Where the pipes are overlaid with rock they need not be of a thickness corresponding to the pressure, since the weight of the overhead material supplies resistance. The pipes are carried into the rock to a point where merely the overlying weight, without regard to any tensile and sheer resistance, is sufficient to withstand the hydrostatic head. By "overlying weight" is meant the weight of rock vertically overhead. In this way reliance is placed on gravitation alone, which is not only a calculable quantity, but can be depended upon to be ever present.

### METHODS OF WORK

When we consider the diversified construction entering into the building of the Catskill aqueduct we are not surprised to learn, in view, also, of the magnitude of the undertaking, that this enterprise involves an equipment approaching that required for such a great achievement as the Panama Canal. In the first place, the boring operations are necessarily on a very considerable scale. Their vital character has already been pointed out. It will be interesting to consider more particularly the methods employed.

To effect the sinking of the hole, we must penetrate the strata, remove the spoil and maintain the wall. This has always been the problem since



WALLKILL DIVISION, SOUTH PORTAL OF BONTICOU TUNNEL, SHOWING BAD ROCK.

the earlier days. More recently the problem has been made somewhat more difficult by the desire to secure more or less permanent samples of the geological layers. Mere penetration is not difficult to obtain. A heavy steel chisel repeatedly lifted and dropped and given a slight rotary movement between strokes has long been known as an effective means. When the material is ordinary rock the maintenance of the wall is also no difficulty. The removal of the spoil has not been so easy. Usually it is accomplished by removing the drill entirely from the hole and putting down a suitable bucket. There is thus no continuity in the process. The wall could be maintained where necessary by driving down metallic tubing. As for securing samples in proper condition, this method is of but little value. But where conditions are otherwise favourable, it is even to-day a pretty good means of piercing the crust of the earth. It is the procedure of the *churn drill.* The chisel or bit which effects the cutting is of hardened steel. Above this is a rather long and heavy stem. Its office is to give direction and force to the blow of the drill proper. It may be anywhere from 10 to 40 feet long. Above the stem is a set of jars, a device whose office it is to jar or jerk loose the bit if it should get stuck. For a moderate depth of hole the three metal parts weigh, altogether, about half a ton. They are lifted and dropped and twisted by means of a rope operated by a suitable device at the surface. This kind of an outfit is simple, requires for drilling proper but two men, and is quite economical. These considerations are sufficient to keep it in favour and permit its use under favourable conditions. Two additional men are needed when the casing is to be driven. What is sometimes an advantage is that but little water is required at the bottom of the hole. However, this drill performs excellent service in going through rock.

The *wash drill* performs its duty in soft material. It operates, in part, hydraulically. The metal casing which is to line the hole is put down by the removal of the underlying soft material through a water jet let down within the pipe. The lower end of the jet pipe is provided with a chopping bit. This is lifted and dropped together with the weight of jet pipe and given a churning movement by apparatus above. The force of the jet mingles with the sand, or gravel, or whatever the material may be, and the return current passing up between the jet pipe and the casing brings the dislodged material to the surface. It will be seen at once that a considerable supply of water is a necessity. In putting down the lining, tubing of full size are first driven, the sections being from 6 to 10 feet long. The lining grows from above, and the driving is effected by a pile-driver operation. The friction against the exterior after a time forbids further penetration. The depth of hole which can be thus lined varies, of course, with the material and the like, a good average being about 100 feet. When the tubing can be forced down no further additional penetration may be secured by putting down pipe of a smaller diameter within the stalled casing. After a time this will reach its limit, and a third smaller line of pipe may be used. The blows given in driving should be light and oft repeated. The pipe is turned between times by means of tongs. The first pipe may be 6-inch, followed by 4-inch, 2½-inch, and perhaps 1⅝-inch tubing. In this way a penetration of, say, 350 feet may be obtained altogether. The heads of all the casings extend to the surface.

The system is well adapted for penetration through surface soils and is economical. It will readily be granted that it is not suited where the material is very hard. When conditions are favourable very rapid progress can be made. Sand is, perhaps, the easiest material to penetrate, as it is easily displaced and readily washed up to the surface. Indeed, if the sand be quite fine and loose, the wash pipe may be removed and the casing itself used as a jet pipe. The return is accomplished on the outside. The casing is continually turned with tongs. In some porous soils the jet may become ineffective, because of want of proper resistance. However, by keeping the foot of the casing close above the end of the jet the difficulty may often be overcome, in part at least. Another difficulty occurs where there is a mixture of sand and cobbles. The sand may be washed out, leaving a cluster of packed stones. The remedy would seem to be in reducing the flow from the jet until the difficult layer is passed. Sometimes a boulder of considerable size is met. It may be necessary to break it up or displace it by means of dynamite.

A diamond or shot drill may be employed to pierce the boulder. It may then be dynamited, the casing having been withdrawn a short distance. In some cases the boulder may be broken up by a dynamite charge placed on top of it. But, as Mr. Ridgway tells us, the withdrawal of the casing may permit sand to flow in and float the dynamite up within the pipe, so that the explosion results in breaking it. The probabilities are that the damage done and difficulty created are beyond repair. A new hole is the solution. It seems that the explosive termed "gelatine" is more reliable than ordinary dynamite. A strong battery should be used and one exploder to each stick. Dynamite sometimes refuses to explode. This phenomenon has been attributed to the chilling effect of the surroundings. It may be necessary, after a failure, to chop up the dynamite. It is said that if the hole is 30 feet or more deep there is no danger. In difficult material the bit at the bottom of the line of wash rods may become wedged, resulting in breakage of the line. A conical recovery tap may be let down and an internal thread turned, if the hole in the rod can be found. If this fails, a piece suitable for turning an external thread may be tried. With a grip made, the rods and chopping bit may, perhaps, be recovered. If the hard bit itself is lost considerable difficulty may arise from its interference with operations unless it can be recovered. With pieces of steel present in the hole it may become necessary to get rid of them somehow. Dynamite may be used for the purpose.

WALLKILL DIVISION, SHOWING END OF CONCRETE WITH KEYS, AND THE ERECTION OF ARCH FORMS

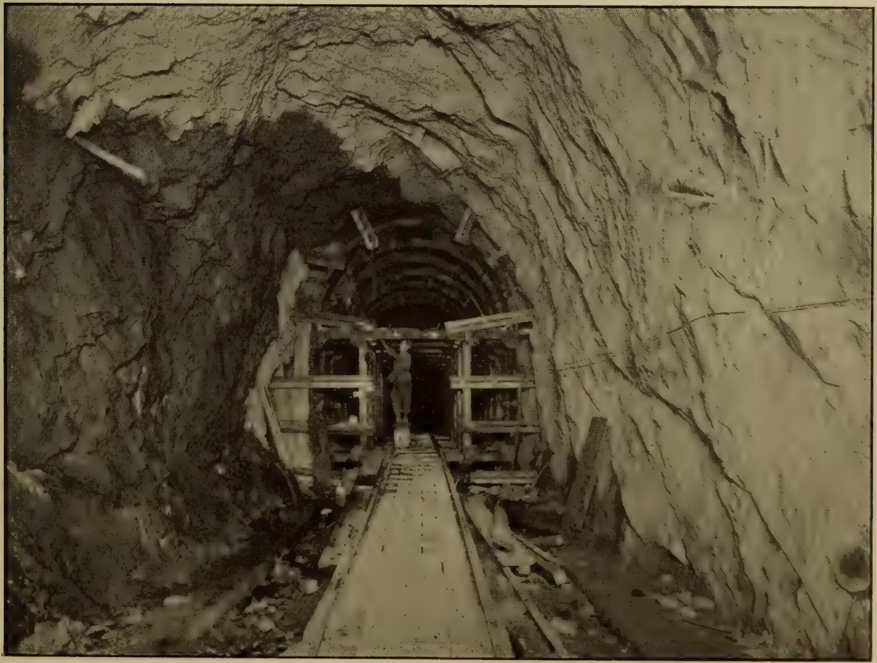
The wash drill is, perhaps, the best type for soft material, in spite of certain difficulties. An experienced operator can judge of the strata passed through from an examination of the washings. These can scarcely be expected to give a very clear indication of what the condition of a given material is *in situ*,

WALLKILL DIVISION, SHOWING METHOD OF CONSTRUCTION OF SIDEWALLS AND ARCH.

but the general characteristics may be more or less accurately judged. Perhaps information as to porosity may be difficult to secure in this way. It would seem as if some method of getting a sample might be devised—a sample not chopped up and saturated with water. A simple means of accomplishing this would, apparently, be of value. When the hard rock is reached its service is properly over. Some other system of drilling must now be followed if penetration is to be carried further. There are three possible methods—the churn drill, the diamond drill, or the shot drill. The diamond and shot drills are unsuited for soft material, so that the wash drill divides the work well with them. The churn drill may be operated as supplementary to any of the others or alone in all kinds of material. The diamond and shot drills are the most modern apparatus for hard penetration. In addition, they secure a core of the rock, showing its condition *in situ.* This is a tremendous advantage, and has been the means of bringing these types of drill to a foremost place. Such cores are often obtained of very considerable lengths—10 feet or more. If the rock is much disintegrated it may be impossible to secure a core, but generally it is possible to obtain such samples of some reasonable length. These may be preserved in their proper order of succession, and will thus exhibit the geologic conditions. This is the thing that is often wanted—and wanted seriously.

To get the casing up after it has been driven, a heavy weight applied upwards may be employed. On some of the Catskill work, at least, the experience seems to indicate that repeated light blows are best. The casing should, however, be put under a heavy stress upwards by means of jacks before applying the hammering action. The jars, combined with the stress, were apparently pretty successful.

As neither the diamond nor the shot drill is adapted for the piercing of the surface soil, operations are quite often begun with the wash drill. The casing must be sunk through the soft material and into the rock far enough to seal it against exterior hydraulic heads. The very first excavation is made by pick and shovel for, say, a depth of a yard. The casing will now be started, and can often be driven to a total depth of, say, two yards, when wash drilling proper is begun and continued until the rock is reached. More effective means will have to be used to penetrate the rock, unless pretty soft, than are afforded by the chopping bit of the wash-drill outfit. Casing may now be dispensed with, however. The hollow rod will continue in use and supply a stream of water, as before. A diamond bit or shot bit will be the cutting tool. There may also be a core barrel, if samples are desired. The operating apparatus at the surface is different, so far as the cutting duty is concerned. A continuous and powerful rotary movement is given to the line of hollow rods, and thus the rotating bit cuts its way. The water jet aids in the cutting and creates a return current which brings the fine spoil to the surface, but does not effect actual excavation. The cutting face of a diamond bit will have, perhaps, eight diamonds arranged around its annular surface. These alternately project slightly beyond the inner and outer edges. It will be seen that the operation of such a tool will result in the cutting of a cylindrical shell, leaving a core of the original rock underground. This core is the sample. A diamond bit is quite an expensive article. Its value, however, will undergo fluctuations, dependent upon the price of the diamonds. Perhaps $800 is a fair value for a bit. The diamond used is exceedingly hard—harder than those usually used as jewelry. Their carat price is considerable, averaging, say, at $60 per carat. The diamonds used will weigh from one to two carats, so that eight have a value ranging



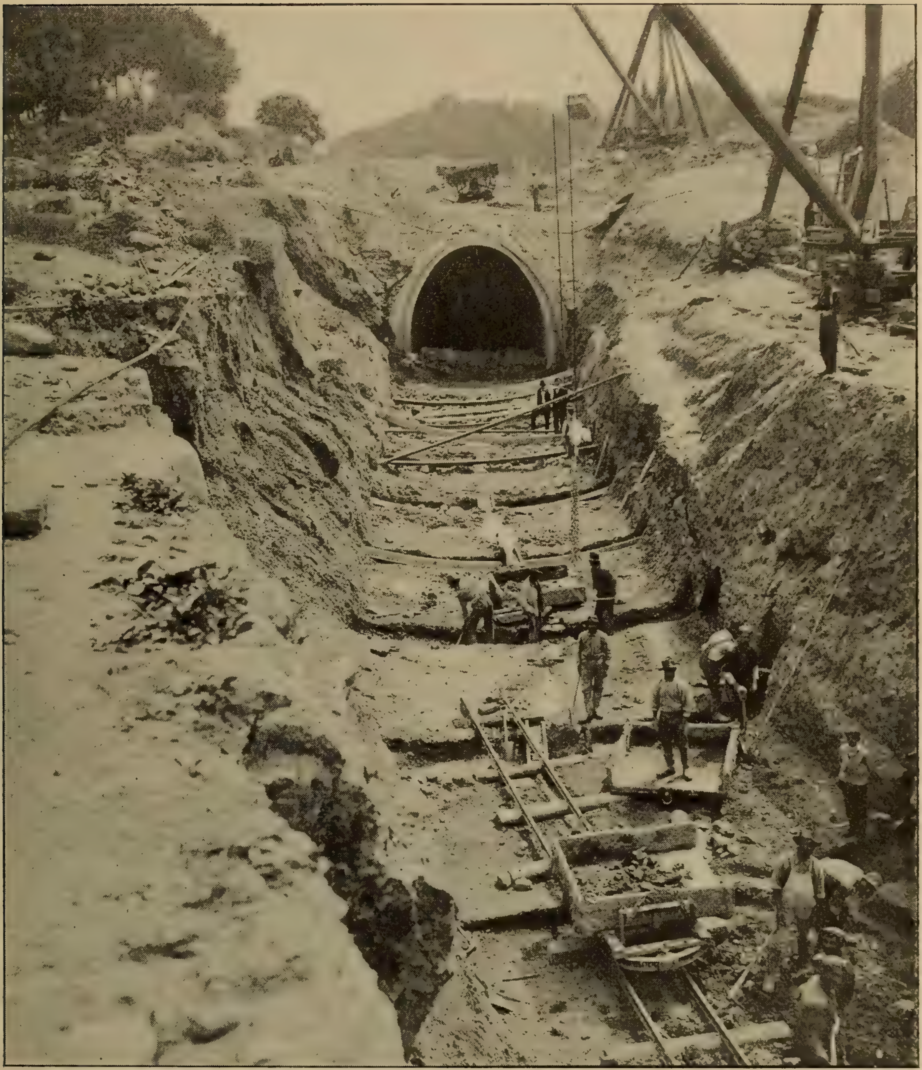
LOOKING NORTH IN BONTICOU GRADE TUNNEL, WALLKILL DIVISION. NOTE FOOTING COURSES AND METHOD OF BRACING FORMS.

from $480 to $960, on the average. The loss of a bit means so many diamonds gone and may lead to difficulty with the hole. The diamond is not tough, but brittle. It will withstand heavy pressure if applied evenly and without shock. It can readily be seen that drilling through seamy rock may become quite unfavourable. If there is much quartz present the abrasion may become excessive. Under ordinary conditions, however, the wear on the diamonds, while considerable, is by no means prohibitive. A case is mentioned where a diamond bit was lost in drilling operations in the Esopus division of the Catskill work. There was encountered a rock cave containing a stiff clay. For a while the clay kept the rods from bending, but as more and more was carried off by the water they bent and broke. The free end of the lower part of the line got so much to one side that it was found impossible to get hold of it, with the result that a $1,000 diamond bit was entirely lost. Of course, the diamonds are worn away as the cutting proceeds, and this constitutes the ordinary and proper loss. But the diamonds may be spoiled by the failure of the water supply. The rupturing of molecular attachment liberates heat, and the grinding away of the rock particles constitutes no exception. The water is needed then as a cooling agent. It is, in fact, a *sine qua non* of diamond drilling. If there is no sufficient supply in the vicinity, it must be brought, even if it has to be hauled. It will thus be seen that the question of water may become a large factor in the expense account. From a consideration of the accidental, unknown, and known factors, one can readily see how uncertain an estimate of cost may be. The local surface indications count. These may be predetermined. But who can tell in advance much about conditions beneath? However, notwithstanding all the uncertainties as to expense, it is a very notable and sure method of getting results. Some contractors will, so it seems, undertake diamond drilling at a previously arranged price per foot.

The setting of the diamonds requires care and skill. The seat must be firm, so as to hold the diamond without rocking. The metal of the bit is soft steel, in which the stones are imbedded and held, the steel being tamped to effect a grip.

An effort, and a successful one for most purposes, has been made to replace the diamond. The substitute is what is known as steel shot. This consists of hard steel in a granular form. The grains are irregular, so that the term "shot" is somewhat of a misnomer. The bit is a steel shell whose lower face has one good-sized notch, so arranged as to catch granular matter at the bottom of the hole where it rotates. When the hardened shot is fed to this bit along with water a grinding action is set up which wears away the rock similarly to what is the case with the diamond bit. Of course, the shot suffers more than diamonds, but it is enormously cheaper. The spoil is not carried to the surface by a return stream of water. Instead, a small amount of water is used and the spoil carried up a short distance to a part of the device known as the calyx. This is an upward extension of the barrel which surrounds the short length of core. The calyx extension envelops the rods and serves as a receptacle for the spoil. The last may thus be drawn up to the surface. To secure the core, a little sand or gravel is washed down the rods, and some of it finds its way between the core and the barrel. Caught between the rotating barrel and the stationary core, it operates to wedge the two together. The core is broken off near the root, and may then be drawn up in its barrel.

It is thought that the diamond drill is more efficient where there is considerable variation in the hardness of the rock. The comparative cheapness of the steel shot, however, makes this system attractive. The

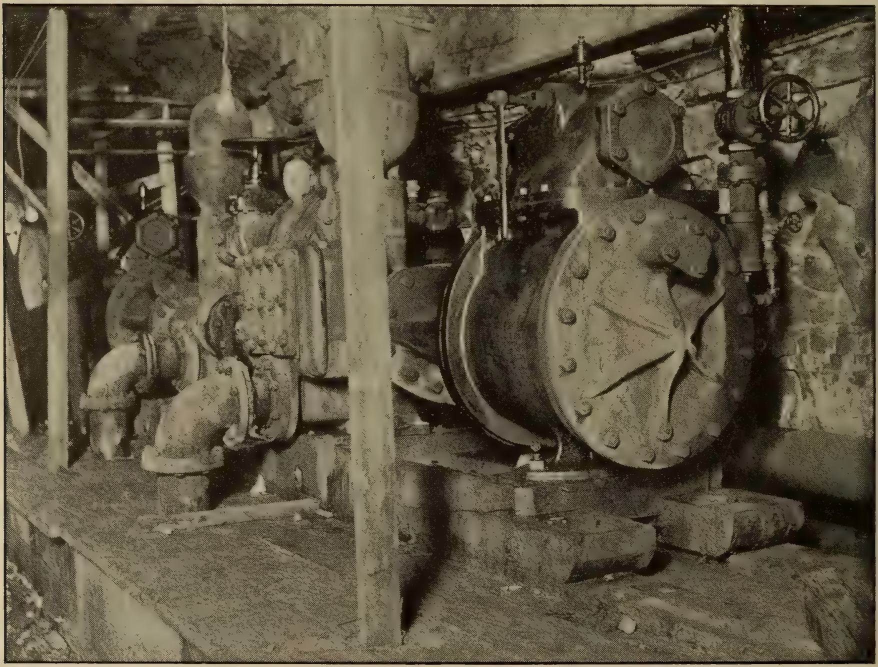


COLD SPRING CUT-AND-COVER WORK, SHOWING CONSTRUCTION OF INVERT

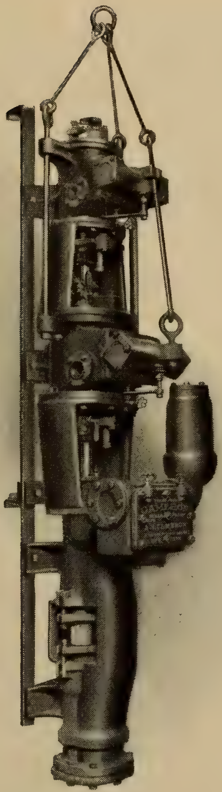
truth as to the comparative value of the two procedures is probably this—one is better adapted for certain work and certain conditions than the other, and vice versa; and both are equally suited for still other work and other conditions. As an example of difficulties with which the shot drill seemed unable to cope may be mentioned certain work connected with the exploratory operations on the Esopus division. There is a bed of Shawangunk grit having a thickness of about 250 feet. This grit is a conglomerate of pure quartz, and exceedingly hard. The drill was able to cut the rock. That is not where the apparently insuperable difficulty lay. There are numbers of seams, in some of which there is running water. When the drill would reach such a seam the shot would be carried off and the grinding effect stopped. Manifestly the diamond drill is the preferable apparatus for such conditions. However, if a large sized hole is desired, the shot drill seems to be more economical. The aqueduct dips beneath the surface at Croton Lake and makes the passage far beneath the bottom of the water. The valley is here about a quarter of a mile wide. Mica schist shows on both sides. In the investigations necessary for the location of the siphon, both the diamond and the shot drills were employed. On each side a large 6-inch hole was sunk by the shot drill. From such cores very complete information of the character of the rock may be expected. The diamonds necessary for a hole of this size would have cost a good deal of money. With the shot drill, however, large holes may be put down at a possible figure.

The results of the drilling showed that zones of crushed rock existed. It was thought possible that such locations might become regions of leakage "through the joints or planes of fracture." The large holes were tested by pumping. The greatest amount of flow was found to be about 50 gallons a minute. The two methods were here employed to supplement each other, the diamond holes being 1⅝ inches in diameter and penetrating the intervening portion of the site. It is proposed to run the bottom of the siphon across in the rock through the zone lying between elevations —110 and —150.

It may be interesting to give some costs for different kinds of drilling. It must be remembered, however, that here, as elsewhere, figures may prove deceptive, because of the variations in conditions. They do have a useful office, nevertheless. In the southern department of the aqueduct the cost of drilling holes with steel shot ranged from $1.14 to $6.52 per foot, the average being $2.40 per foot. We thus see that much the greater part of the drilling was accomplished nearer the minimum cost. The "labour supplies and a percentage of the total cost of the plant for depreciation and repairs" are factors taken into account in the figures given. The expense for drilling with the dia-



A CAMERON STEAM PUMP IN THE AQUEDUCT TUNNEL



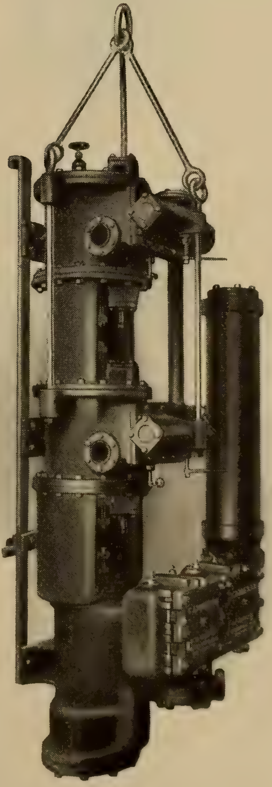
CAMERON TANDEM DOUBLE STEAM END VERTICAL PLUNGER SINKING PUMP.

mond was, estimating on the same basis, $3.62 per foot. These costs are based on a total of about 5,000 lineal feet of holes. It is said that the average depth drilled per day was 5 feet for each machine. Wash drilling on the land is said to have cost the contractor $0.41 on the site of Kensico dam and $0.80 on the site of a nearby dike. On the water, the average depth being 20 feet, the wash-drill holes were put down at an expense to the contractor of $0.22 per foot.

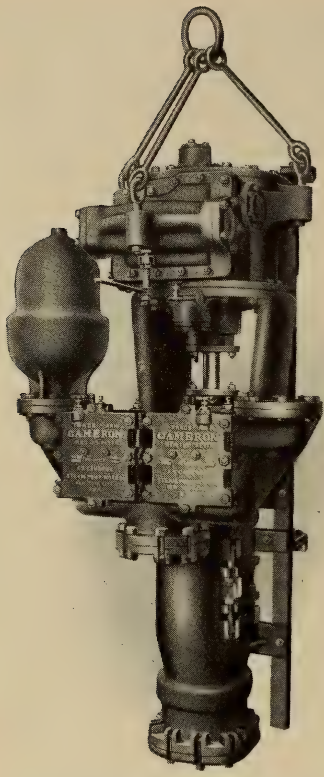
Drilling by contract has been done at $3.50 to $4 per foot. The seventy-four borings, aggregating a length of 8,300 feet, put down on the subsequently rejected Tongore site for the Ashokan dam, are, in effect, said to have cost an average of about $3.50 per foot. The 150 holes, totaling a length of 11,500 feet, on the site where the main dam of the Ashokan reservoir is to be located, averaged about the same.

The work which is being done by the contracting firm of T. A. Gillespie Company, at High Falls, N. Y., required the installation of a very large pumping outfit, and fully 75 per cent. of the many types and sizes of pumps used were Cameron pumps, furnished by the A. S. Cameron Steam Pump Works of New York.

At the start four shafts were sunk, through rock, ranging in depth from 450 to 700 feet, and during the progress of the work large quantities of water were encountered. To meet these emergencies the Gillespie Company used a special type of Cameron pump, known as the tandem double steam end vertical plunger sinking pump, which was operated by compressed air. With this type of pump the work is done at first by the use of



TANDEM DOUBLE STEAM END VERTICAL PISTON SINKING PUMP. A. S. CAMERON PUMP WORKS.



CAMERON VERTICAL PLUNGER SINKING PUMP.

the upper 19-inch diameter tandem steam cylinder alone, while the lower cylinder reciprocates idly, until a depth is reached in the shaft requiring more power to operate the pump; then the air pressure is turned into both cylinders, and the pump continues its work until the maximum depth is reached for which the pump was proportioned. This pump is made in both the piston and plunger types, and the size used by the Gillespie Company was 19 by 19 by 12 by 16, each competent to discharge 450 gallons per minute 600 feet high, weighing about 9,000 pounds each, and requiring about 2,000 cubic feet of free air per minute. This pump did very satisfactory work, and required very little attention and care.

In addition to this type of pump the Gillespie Company also used for shaft sinking, at various depths up to 700 feet, Cameron vertical plunger sinking pumps, size 24 by 10 by 16, weighing about 8,600 pounds, which gave very effective service in handling the gritty water.

When the work of sinking the shafts referred to was completed, the horizontal tunnel work was rapidly conducted. To take care of the water encountered in this work heavily-constructed Cameron piston pumps of large capacity were installed, most of which were located near the bottom of the shafts. The fact that the bushings or linings in the water cylinders of these pumps were removable made it possible to easily and readily renew them without disturbing any of the pipe connections, which permitted the work to be continued with the least delay—an important consideration in work of this kind.

While it would be difficult to say how many gallons of water were handled in a day on this job, yet some idea can be had as to the quantity of water pumped from the fact that there were more than fifty Cameron pumps alone installed, ranging in capacity from 60 to 600 gallons a minute each, under varying conditions of service.

(To be concluded.)

# THE GREAT TRANSFORMATION

### By Henry Harrison Suplee

## IV.—THE TRANSFORMATION IN ARCHITECTURE

WE have seen how the influence of unrestricted aerial navigation may be expected to transform both the peaceful conduct of commerce and the destructive activities of warfare, and pointed out that the command of the air may lead to as effective an elimination of national conflicts as already exists in personal relations. There is, however, a phase of the great transformation which may come closer than either of the foregoing to every individual, the transformation in the buildings in which we are to live and work.

There is probably no detail of human construction which has been more definitely influenced by the limitations of human position than that of the design of buildings and similar structures. The earliest huts doubtless have their counterparts in the rude structures of present savage tribes, and it is one of the evidences of advancing civilization that the higher orders of mankind invariably endeavour to make taller buildings, and to get away from the surface of the earth and up into the heavens. The legend of a tower that should reach to the sky is evidence of this tendency, while the authenticated Hanging Gardens of Babylon and the aspiring towers of many later buildings all bear witness to the appreciation of men of the upper spaces of city or country. Apart from this tendency, however, the fact that man himself has hitherto been compelled to move principally upon the surface of the earth has imposed a definite limitation to the point of view of all buildings, and hence has exerted a controlling influence upon all architectural design.

All training in architecture within historical times has taken as its initiative the appearance of details and ensemble from some point upon the surface of the earth. The classical orders depend for their effect upon the peculiarities of human vision directed from below upward, while the impressive influence of the Gothic vaultings is due very largely to the perspective from the pavement. All designs of façades assume the position of the spectator to be in front of the building, and the development of the tall business building in the great city has involved the peculiarly difficult task of providing an effective front from the viewpoint of the observer on the opposite side of a narrow street.

This attempt to produce effects from below has led to some curious methods of design and construction. Heavy overhanging cornices, originally forming a structural part of massive masonry buildings, are now frequently made of thin sheet metal, bolted fast to brackets of structural steel and painted to correspond to the general effect of the shell of the steel cage construction. Details resembling elaborately carved stone, sufficiently bold in design to be evident from below, are likewise made of sheet metal and attached to framework or balcony in a manner not unlike the methods obtaining in theatrical stage settings. These are but isolated examples of the manner in which it is tacitly assumed that buildings are expected to be seen almost entirely from the surface of the ground, and that the unlovely reverse of the picture is not to be looked at.

In these days of isolated tall buildings and towering structures the hideous ugliness of the tops of most of our large cities is being laid open to view, and the sham character of the so-called ornament appears before the eyes of a limited number of the inhabitants. When we realize that the general utilization of aerial transport will change the viewpoint of the great majority, the influence upon architectural design may be faintly perceived.

The spectator who stands upon the upper portion of one of the modern tall buildings and gazes down upon the tops of the surrounding houses sees many things which would never have been permitted if the architect had understood that the point of view was to be from above. Chimney-pots, tanks, elevator head-houses, skylights, trapdoors, ventilators and the like appear in the midst of sham cornices, imitation parapets, ladders, platforms and other crudities, which, until recently, have been unobservable from the ground or from other usual points of view. As the opportunities for perceiving these back-yard effects become more general it is certain that some attempt will be made to give a more seemly aspect to the tops of existing buildings, and with the general removal of the viewpoint to the higher elevation the methods of design must surely be modified.

Already a certain number of photographs of important cities, taken from above, have been published, and serve to show how these places really look when a good opportunity to see them is afforded. The freedom with which architects and builders have felt able to neglect the tops of buildings, upon the supposition that they cannot be seen from below, is doubtless responsible for much of this unsightliness, but there are other and more profound reasons.

There are few departments of industry which are more closely influenced by precedent than the building art. Nearly every generation, from the earliest times, has copied from its predecessor, and while there has been a continual growth the buildings themselves form a record of the manner in which the styles and methods of one period have overlapped each other. It is unnecessary to discuss here the extent to which the masonry construction of Greece was developed from an earlier timber framework, or how the Gothic school was evolved from the Romanesque, or how the period of the Renaissance re-introduced ancient classical ideas. It is sufficient to note that the entire history of architectural training tended to produce men imbued with ideas of past ages, and only by the influence of isolated and independent individuals were new ideas and combinations slowly evolved.

In recent years, however, and particularly in newer parts of the civilized world, the influence of engineering development has shown itself powerful in the modification of architectural methods, mainly by the extent to which new principles of construction have been produced. The extending use of skeleton steel construction, relieving the walls of the principal burden of weight and distributing the load over the entire area of the structure, has made the tall building possible and permitted the employment of light enclosing walls of brick, tile or concrete. Structural improvements alone, however, would not have made these changes practicable, and it remained for the perfection of the high-speed elevator to place the upper floors within reasonable access from the ground, and even then the invention of telephonic communication was necessary to permit men to remain in their offices and residences in these far upper stories and communicate throughout the city and country. Thus the work of the engineer has exerted, in this single department of architecture, an influence more far-reaching than any which can be traced to considerations of mere artistic effect.

When such buildings were produced the efforts of the architect were strained to treat them in such a manner as to give any real beauty to the structure. In some cases, especially when the building fronted upon an open space or park, the opportunity of a fairly distant view made the tower-like construction manageable; but such locations are the exception, and in some cities the tallest buildings have been erected upon the narrowest streets, rendering any observation of the upper portion from the ground almost impracticable. In certain well-known cases the problem has been frankly abandoned, and a crude brick, chimney-like edifice, without any claims whatever to artistic design, accepted as inevitable.

If such difficulties have been encountered in connection with mechanical developments which affect merely the construction of a building, what changes may not be anticipated when the entire viewpoint is transformed? As has already been indicated in connection with the transformation in military affairs, the "front" is to be replaced by a "top."

Le Sage, in *Le Diable Boiteux,* describes the appearance of Madrid when, at a wave of the hand, all the buildings were thrown open from above, and this fantastic creation of the imagination may yet be permitted to remain within the domain of fiction.

If, however, the general and convenient points of access, of vision and of service are to be the tops of our buildings and not the portions near the surface which face the streets, there must come an absolute transformation in construction, interior arrangement and artistic treatment.

In our present cities there is, as is well known, a building line, determined according to the surveyor's plan of the street, beyond which the individual structures may not project; but there has been no necessity for regulating the absolute heights of the different houses. It is true that in some places there is a limitation placed upon the maximum heights of buildings, this being either an arbitrary amount or a function of the width of the street upon which the building is erected. These restrictions, however, have not been accompanied by any rules controlling uniformity, either in height or treatment of upper surfaces, and hence the tops of all present cities present an irregularity wholly incompatible with the impending change of front. It is not only the change in the situation of the "frontage" of buildings, but the transformation in the character of the exposure, which demands attention. The busy highway of today, crowded with vehicles, from the ponderous omnibus to the speedy runabout or motorcycle, is already becoming a thing from which the householder turns with combined feelings of distrust and discomfort. If such be the case upon the surface, where the limitations are well defined, and where some effort at police regulation may still be maintained, what may be expected when the upturned face of the entire metropolis is laid open and bare to the uncontrolled sweep of the aerial machines?

It is too soon to answer these questions definitely; indeed, it is probable that they will not be answered directly at all, but that the solutions of the many problems involved will have to work themselves out in the course of a development which may seem slow as things are moving nowadays, but yet be well within the experience of men now living. Already the danger to certain kinds of structures from falling débris from aerial machines has become the subject of discussion and demand for protection. The incident of the two adventurous aeronauts who fell through the roof of a quiet German residence may be recalled, and while these things are yet curious occurrences, isolated from general life, they may be compared with the automobile accidents of a few years ago.

Some of the changes in the uses of buildings under the changed conditions may serve to indicate the lines along which modifications in construction will occur. At first the principal thought will, doubtless, be that of protection against damage from falling machines or substances, but with this will doubtless appear a desire to make the tops of buildings points of observation, and also for use as landing platforms. With the exception of certain experiments in the matter of alighting upon the decks of vessels, this latter point is one as yet hardly considered, the present-day aviator choosing his landing place where it seems most convenient. Doubtless, one of the earliest features of more fully acquired experience will be that of descending at any desired point, preferably upon the top of the owner's dwelling; and, in any case, the present irregular character of the upper portions of buildings makes descent in a city most dangerous, whereas it should be made most convenient. Public spaces, to and from which machines may be operated, will probably come first; but one of the greatest advantages of aerial transport, as has already been noted, will lie in the possibility of making the complete journey from individual terminal to individual terminal, and any limitation of terminus would be as objectionable for the flying machine as it would be for the automobile.

It is probable that for a long time to come the delivery of heavy material into buildings will be made through entrances upon the surface of the earth, and thus a certain detail in the design of the lower parts of buildings will be determined. Personal entrance and the delivery of lighter material will gradually be transferred to the top, being landed from above and kept away from the ground, and thus a differentiation of interior arrangement will naturally follow. It is probable that the extreme upper stories of buildings under the new arrangement will be the most desirable, in the cities at least, and will include the gardens, landing platforms and points for the reception of visitors. Some indication of this modification may be seen in the so-called roof gardens already in use upon the tops of hotels and theatres in the United States, and the popularity of these places during the warm season shows how greatly the rearrangement of the roofs might conduce to the desirability of the new order of things. It is evident that even such a minor change would modify very materially the whole architectural scheme for such buildings, since the principal aspect would be from overhead, and the street front, upon which the architects and decorators have hitherto expended their principal efforts, would be unobserved and of minor importance. Probably the lower floors of buildings would become less and less desirable for residence or for retail business, and the segregation of various industries into layers according to the nature of the work may be indicated.

The transformation, however, will doubtless be far more profound in its ultimate effects, and it is altogether probable that the general development of an independent method of transportation through the air will have much to do with a general change in the distribution of population and industry. The ancient remark as to the fact that "great rivers nearly always run by large cities" may be invoked as bearing upon one of the earlier reasons for urban growth, while it is certain that the development of railways has borne a large part in the concentration of population which forms so significant an element in social affairs of the last quarter-century. Not all mechanical developments, however, tend to produce congestion, and it seems as if some of the later appliances were acting to undo the effects of their predecessors. The influence of the automobile upon the conduct of affairs has been referred to frequently in these papers, partly for the reason that its effects have been produced within the most recent period of observation and partly because those effects partake somewhat of the same nature as those which may be expected in consequence of the increased use of the aerial machine. One of the most marked influences of the extending use of the motor car has been the dispersion of population which it has made possible. The railway has led to the extension of certain phases of suburban life, but the extensions which it has made possible have been limited to points closely communicating with the lines of the railroad itself. The automobile, giving access to every highway and branch road, and aiding in the development of new and better roads in all directions, has done still more to draw people away from the large cities, and it seems probable that a large portion will continue to seek homes away from the congested centres and leave the great towns to be populated, to a great extent, by the operatives and workmen, who cannot be separated widely from the places of their daily activities.

An influence similar to that which the automobile has exerted, and which is still more likely to appear, will be produced even more powerfully with the development of general personal transport through the air, and it seems as if a decentralizing action may follow, concerning which more will be said hereafter. This dispersion of population is bound to have a most important influence upon architecture, and the character of buildings, which are to be seen both from the surface and from the air, and which are to be approached principally or even wholly from above, must be very different from that of the earlier time.

One of the reasons for the existence of the modern skyscraper—a type of building which no one has attempted to excuse because of its beauty or general desirability—has been the high value of the ground on which it stands and the necessity of causing the building on the expensive ground to earn a sufficient income to warrant its existence. Thus, a form of structure which has no claims to architectural beauty may possibly be rendered unnecessary if improved transport methods reduce the local congestion which has influenced land values to the disadvantage of the best uses of the ground. The telephone, the motor car and the aeroplane may thus unite in aiding to disperse the crowds in our present type of cities, and thus facilitate industries and commerce, while at the same time transforming architecture and making for better, more beautiful and more wholesome buildings in which men are to spend much of their lives.

The value of special sites may be determined hereafter rather by considerations relating to the use of the property than by access to it. At the present time the advantages which great avenues or desirable streets give to building sites often form controlling considerations in the selection of locations. If, however, the principal access is to be had from above, the street entrance becomes secondary, and may be used, as has already been indicated, mainly for delivery of bulky and slow-moving material, while the open top of the entire area, whether buildings or grounds, remains altogether independent of any other means of entrance. Controversies as to "rights of way" and routes of surface entrance, such as streets, roads, alleys and the like, must become of minor importance. It would be entirely possible for a desirable site to have no surface access whatever and yet be fully open to entrance from above, no method of closing off the aerial route being practicable.

It will be seen that such considerations as have been noticed above also apply in connection with the opening up of sites, most desirable in themselves, but hitherto barred by reason of the difficulties of access.

Man has long envied the ease with which the larger birds have been able to choose their homes upon elevated locations, to which he can work his way only by laborious exertion and great risk; but with the possession of similar means of travel the entire surface will be opened up for his exploitation and use.

It is not to be expected that architects in active practice will undertake to modify their designs in accordance with coming changes until there is a demand created by their clients. Probably the first thing to be required will be the design and construction of "hangars" or houses for flying machines of various kinds, and the production of such buildings will progress much in the same fashion as has already been seen in the case of garages for automobiles. Probably the plans for city houses will, before long, include entrances and housing for automobiles, and later there will appear the hotel, residence, and club house with suitable arrangements upon the roof for the reception of the alighting aeroplane. Before this stage of the change is reached, however, there will probably appear the landing place, as a feature in country houses, inns, and points at which flying machines may be expected to stop upon the more direct routes between the principal cities and resorts. Thus a gradual development will doubtless appear, leading up to the general change which the altered mode of transport will produce.

Here, again, care should be taken to perceive that the location of such landing places may be only remotely connected with earlier methods of travel. It is doubtless true that the principal starting and alighting places should be convenient of access upon the surface, but many points along the main routes will doubtless be considered on account of the convenience which they afford to the machine in the air rather than to the machine upon the road.

The architect, as usual, will doubtless follow the demand, and not attempt to create it, but when the principle of the overhead viewpoint is accepted, as displacing the older one of the station upon the surface, an entirely new kind of architecture must surely follow.

The changes which aerial transport may be expected to make in the domain of architecture may, then, be summed up as follows:

The point of view of most of our buildings will be changed, causing the upper surfaces to become the actual fronts and form the principal portions for access and architectural treatment, and compelling the present neglected and unsightly tops to disappear.

The appearance of buildings from points on the surface will become of minor importance, and thus lead to a treatment of the vertical walls, especially in the lower part, based wholly upon utilitarian considerations, much as the roofs have hitherto been considered.

The upper stories will become the most desirable for residence, retail commerce and popular usage, causing a corresponding change in the interior arrangements of buildings.

The dispersion of population possible by reason of the improved transportation facilities will develop a new type of building, adapted to overhead access, and yet more isolated from its neighbours than has hitherto been considered desirable with ordinary means of transport.

(To be continued.)

# LARGE STEAM LAUNDRIES

By F. T. Johnson

There are many departments of industry which have grown from the ordinary limitations of hand work into the dimensions of manufacturing, and the knowledge of which is limited to those directly connected with the actual work. Thus, the subject of laundry work, as now conducted upon the large scale, as for hotels, steamships, hospitals, and other institutions, has led to the development of special machinery for the purpose, and the following article, treating of present British practice in this special department of work, will be found typical of the apparatus and methods in the leading large cities on both sides of the Atlantic.—The Editor.

IT may be a surprise to some and of interest to others to be made acquainted with the immense amount of engineering skill which has been evidenced and expended on the design and in the construction of machinery for washing and ironing clothes.

The paucity of the amount of informative literature in connection with this particular section of the engineers' profession is most marked—one disposing cause of this being that experts in this business (as in several others), comprising only a very limited number of firms, are averse to giving away the results of their costly experiences, excepting to bona fide clients and purchasers of their manufactures.

These experts may be in no way to blame; they are perhaps fully entitled to the protection their trade secrets afford, but it is hardly possible that these secrets can remain so for long.

There are those who, as work managers, etc., possess the advantage of considerable and valuable experience in connection with this class of work, and the writer is among the number. There can hardly be two opinions in reference to the right which such works superintendents have to give the benefit of their experience to technical and semi-technical readers.

It is true that very few of the reading public and, in fact, not many engineers, are at all cognizant of the unusual dimensions and cost of the plant which some of the large laundries attain; and when laundries are spoken or read of their minds turn to diminutive buildings, with a few wash troughs, mangles, laundry maids and Chinamen, not for one moment dreaming that some power laundries cost, to erect and set to work, £25,000. There are laundries in Great Britain and in Ireland, especially those which are adjacent to the large shipping centres and to the big hotels, in which the whole of the textile washable articles belonging to large liners or hotels, may be taken and disinfected, washed, ironed and folded and returned in twenty-four hours; the number of articles, such as sheets, blankets, tablecovers, serviettes, glass cloths, lace and other curtains, aggregating many thousands of pieces. It is a noticeable feature, too, that such a great task is accomplished, contrary to the generally accepted idea, with a minimum of damage to the cleansed articles; it is, indeed, a creditable performance.

It must be admitted that some laundry machinery which has recently come on the market is far from being a credit to its producers; there are firms who make a distinct specialty of the very best machinery, of its respective class; costly, but good; higher-priced than others, but worth it; all got up in the very best style and produced, except in one case, by fully-rated machinists, fitters and erectors. From the steam boilers, all along the line of disinfectors, filters, steam engines, and right down to less important but necessary details, all is of the very best material and workmanship. Nothing is manufactured and sold but has had every defect, all possible cause for trouble and inefficiency or danger eliminated.

The boilers, engines, transmission gear, the rotary washers, the immense ironers, the dolly-washers, hydro-extractors, and drying rooms, the splendidly-built mangles with polished stone beds, the shirt, cuff and collar ironers—all are the outcome of costly experiment, enabling the manufacturers to supply their clients with goods which may be relied on, and which may be tended by only partially skilled operatives.

### DESCRIPTION OF THE PLANT.

The boilers are usually of the Lancashire or Cornish type, being intentionally provided with ample steam and water space, for the purpose of supplying steam and hot water for washing purposes, as well as for the steam engine which provides the motive power.

The steam engines are generally of the horizontal class, and great attention has been given these for the purpose of rendering them extremely economical, resulting in a type of engine which takes rank with the best for durability and economy.

The disinfector is a most useful and necessarv acquisition to the large power laundry generally, and for those in connection with hospitals for infectious diseases and for lunatic asylums it is indispensable. It enables the responsible authorities to deal effectively with filthy and infected clothing of such institutions, previous to being passed to the washing plant proper. The germ-destroying factor, which is the essential feature of the disinfector, is the heat of high-pressure steam, the steam being supplied from a special type of vertical boiler.

The disinfector is made in the form of an ellipse, with its conjugate axis vertical, and is about 8 feet in height with a transverse width of 5 feet. It is constructed principally of steel boiler plate, and has an inner and an outer shell, with heavy steel rings, of oval form, riveted between, leaving an annular space between the inner and the outer shells similar to that of the firebox and shell of a locomotive boiler. The infected clothes are taken in on wheeled horses by way of the infected department of the hospital, and the heavy steel doors are quickly closed and fastened, being made steam-tight with rubber ring joint, and pressure being effected by a simple system of hinged bolts and nuts.

Air is then exhausted from the chamber, the object being, by the effect of the partial vacuum, to lay open or expose the interstices of the infected clothes, etc., ready for the disease germs to be operated upon by the action of the high-pressure steam, previously referred to. This steam at a pressure of 75 pounds per square inch is admitted and the germs are thus exposed to the destructive influence of a temperature exceeding 300 degrees Fahr. for about twenty minutes, and then the steam is allowed to escape. This polluted, exhausted steam, for essentially sanitary reasons, is conducted to the fire of the vertical boiler (which has generated it) by way of copper pipes, which pass from the shell, across the water space, into the firebox. To complete the process of disinfection steam is admitted to the annular space between the inner and the outer plating of the disinfector, exposing the germs to the destructive action of air, at steam heat, and at atmospheric pressure. Such disinfectors, with boilers and conducting pipes complete, are supplied to purchasers in many parts of the civilized world, and during the raging of serious epidemics, such as smallpox, typhoid and diphtheria, and other epidemics, they are in great demand by the municipalities.

The machines which rank next in importance to the disinfector in a large laundry are the rotary washing machines. These are beautifully constructed, externally of steel plate and internally of polished copper. The rotary washer as a single unit consists of a strong, steam-tight casing, built of 5/16-inch boiler plate and riveted, and sufficiently strengthened to enable it to withstand safely a pressure of steam up to 50 pounds per square inch. The internal cage in which the clothes are placed is made of copper rods, well cleaned and polished, having their ends attached to "carrying plates," these plates being attached to journals through which the cage is driven. The cage is also provided with "obstruction" ribs to prevent the "roping" (or clinging together) of the articles being washed.

Water and high-pressure steam are admitted to the casing, the casing also being provided with an easily-closing steam-tight door. The unit is fitted (with the object of rendering it safe to the unskilled) with a reducing valve, dead weight safety valve, and a Bourdon pressure gauge, and provision is made so that the machine cannot be started until the steam-tight door is closed.

The rotary washers are made in sizes of 33, 42 and 59 inches diameter of casing, and are designed to be driven by belt, either singly or in pairs. They are provided with automatic reversing gear for the purpose of allowing the internal copper cage to be run a few revolutions in either direction alternately, giving to the clothes, etc., the tumbling action so necessary to efficient cleansing.

The hydro-extractor comes next, and, as its name implies, it is used for the purpose of extracting the removable water from the clothes by centrifugal force. The articles are placed in a strongly constructed cage, or basket, which is made to rotate at a high rate of speed by belt or direct-connected engine. The water thrown off is caught by a strong cast iron pan and thence drained away to waste. Great attention has been given to the efficient development of these extractors in reference to economy of driving power, accurate balancing and fine and convenient adjustment of the vertical step, on which the main shaft rotates.

The drying closet is next in importance and is a more imposing piece of laundry plant than would be supposed. It is a structure of considerable dimensions, built of brick on three sides and having a well-drained cemented floor. A substantial air-tight roof is also provided. Much ingenuity has been exercised in the design and construction of the front of the closet. It consists of six, nine, twelve, eighteen and, sometimes, twenty-four distinct and separate doors, according to the general dimensions of the plant. These doors are of light cast iron, with alternate rebates, on either side, and are 7 feet high by 12 inches wide. Each door is provided with rails, or "horses," such rails being carried at the back of the closet on a light steel galvanized plate, equal in height and width to the front door. On these rails the half-dried articles are duly hung, and each and every door may be separately manipulated, *i. e.,* drawn out on outside runners and rails, emptied of clothes and filled with others to be dried.

The heating of the closet is effected by extensive multiple steam-heated coils, either of the ordinary class with ends attached by "U" bends and flanges, or by the "Sturtevant" system of pipes and cast iron headers. These coils are tested to 120 pounds per square inch, and are efficiently drained of water by a steam trap. The cost of manufacture of these coils has been reduced considerably by having the "U" bends and flanges cast with "gas" threads in them. They are used direct from the foundry, and no machinery of any description is allowed on them. The vapour arising from the clothes is mechanically drawn from the closet by an exhaust fan, scientifically arranged in conjunction with a "duct" for dry air, it having been early known by the manufacturers to be impossible to dry effectively clothes by simply heating them. The air loaded with vapour must be withdrawn mechanically, and dry air must be propelled or induced to replace it.

The ironing or calendering machine should have particular notice, as it is a most important accessory to the large modern laundry, and it may be said that no plant is complete without it. These machines often attain ponderous dimensions, and the work they turn out is of a high order.

Their purpose and office is (by a process of calendering) to give a fine, glossy surface to such washable articles as tablecovers, large curtains, and other plain articles of considerable dimensions. Much might be said in a solely technical article in respect of these useful machines, but only one or two interesting details will be referred to here. The principal details are the end standards, the heavy steam calendering trough, the roller, the feed bar and the raising gear. The end standards are of cast iron, with journals faced, bored and bushed with phosphor-bronze to take the roll bearings. They are set apart to such a distance as is required to suit a roll 52, 80, 108 or 120 inches in length.

The trough is of crescent form (looking endwise) with annular section, and is made of sufficient length to extend somewhat beyond the length of each respective roller. It is cast of the very best close-grained iron, having an inside and outside thickness of ample dimensions to withstand the working pressure of steam, which is used for heating it. There is a space of about 6 inches between the concave surface which composes the ironing surface and the part which forms the bottom of the trough. The two thicknesses are lightly, but strongly, "stayed" by cast iron strengthening pieces, cast inside, while the ends are closed by steel joint plates.

The troughs, though strong, must be sufficiently flexible to provide for the slight alteration of form due to the ever-varying temperature to which they are subject when in operation. The concave surface must also be capable of receiving a fine polish and have an absolutely steam-tight ironing face.

The troughs are bored in pairs, one superposed on the other, with a boring bar having a traversing head, and after the feet have been machined they are passed to the testers. These test the troughs wih hydraulic pressure up to 120 pounds per square inch. Frequently some of the internal stays break under the pressure stress, and it is a question of considerable importance and requiring keen discrimination to judge whether a particular trough with several broken stays is safe to "pass."

As, with other expensive machinery details, it may be suggested that the financial viewpoint considerably assists the superintending engineer in giving a decision, though it may be accepted as an absolute fact that none are sent out for use which are not deemed safe. The trough, having been carefully "passed," is turned over to the "filers." This is a class of men who are not mechanics and quite distinct from fitters and who are paid at about two-thirds of fitters' rate. They use no chisels, hammers or tools of precision, only files and emery cloth. Their work, when applied to laundry machinery, consists in polishing the previously bored troughs on their concave ironing surfaces and then to return them to the testers.

Steam at 45 pounds pressure per square inch is let into the troughs for the next test; and very precise and particular the operator must be, as it is imperative for the purpose of good ironing that not a particle of steam, or even vapour, should leak from the steam space to the concave calendering surface. But not one trough in twenty is perfectly dry and steam-tight, and leakages which are visible are at once remedied by peening, while those that are imperceptible to the naked eye are made visible in an ingenious and interesting, though simple, way. The examiner takes in his hands a piece of clear glass about 6 by 4 inches, and passes it over every square inch of the concave area. He holds one edge in close contact with the polished surface, leaning it forward, to an angle of about 45 degrees. The moment the glass passes over a leaky spot it becomes dulled and the tester is able, by gradually reducing the circumscribed area, to locate definitely the exact spot that requires peening, and proceeds to effect the remedy.

The rollers are made of good gray cast iron, some weighing a ton. They are studded at each of the ends and fitted with substantial cast iron ends, having steel hollow journals, hydraulically forced in. The rollers are tested with water to 120 pounds per square inch, the working pressure being 10 pounds per square inch. When in working order they are clothed in a specially prepared blanket and calico covering, and, though the rollers should be practically steam tight, a slight leakage is not so prohibitive here as in the troughs, for the simple reason that the trough and not the roller is the effective calendering means.

Water is drained away by an ingenious method of splayed scoops and pipes, arranged so that they meet the water as the roller rotates.

The feed-bar is a controllable attachment fitted in the front of the machine, and is manipulated by a treadle by men or women feeders, its purpose being the feeding of the articles to be ironed into the machine, carrying them into contact with the blanketed roller, while the friction between the blanketed roller and the article being ironed takes it through the trough, calenders it and delivers it to the "takers off" and producing the beautiful ironed surface for which these ironers are noted.

The porcelain troughs, the bluers and the rinsers, the mangles, cuff and collar ironers, etc.., are to be found in much smaller laundries, and do not claim description under the head of large steam laundries.

# THE NEW BRITISH RULES FOR THE USE OF ELECTRICITY IN MINES

(FROM A CORRESPONDENT.)

INDUSTRIAL legislation in Great Britain has not always been an unmixed blessing. Designed with the twofold object of protecting the interests of workmen and of minimizing their risks of bodily danger from automatic machinery, it has been found in a great many cases that departmental rules and regulations do not bring benefits commensurate with the drawbacks to industry resulting from its being saddled with factory rules. The use of electricity in mines, however, is in a class by itself. The conditions are quite different from those obtaining in works where most of the staff have more or less technical knowledge, and where a comparatively high standard of maintenance and supervision is, in any case, necessary and observed. Underground, besides the danger of explosion, there is a greater danger of mechanical injury and of shock than in surface work, and as regards the apparatus itself the conditions to be met with are much more severe. It must be admitted, therefore, that if electricity is carelessly installed so as to produce open sparking, serious accident may occur, and hence there is perhaps more justification for special rules for the use of electricity in mines than in other places.

Many colliery managers early realized some of the advantages which electricity offered in increasing the efficiency of coal cutting and coal raising, as well as for the various other operations in a pit. But, owing to the intense conservatism of this class, and also to the low standard of work in many early installations, its adoption in the pits of Great Britain has been nothing like as rapid as it should have been. In addition to this there exists in many quarters a somewhat vague, though unfounded, fear on the part of the miners and managers of this new force. That this objection cannot be justified is shown by the fact that only 1.54 per cent. of the fatal accidents in mines arises from electrical causes, and almost in every case where such accidents have arisen they are shown to be the result of faulty apparatus or other preventable causes.

There are, therefore, special reasons for welcoming the new code of rules governing the use of electricity in mines just proposed by a special committee appointed by the Home Office in October, 1909, to inquire into the subject. This committee consisted of Mr. R. A. S. Redmayne, Chief Inspector of Mines; Mr. Charles Merz, M. Inst. C. E., and Mr. Robert Nelson, one of His Majesty's Inspectors of Mines.

It naturally occurs to ask why any changes should be made, and to examine the changes proposed to existing rules. We might as well state at once that our examination of the report leads us to the conclusion that the rules, if adopted, will add somewhat to the cost of installing electricity in mines, but that they will largely reduce the cost of working and maintaining the apparatus. The committee point out that most of the faults of electrical apparatus in the past have been mechanical rather than electrical. Attention to the mechanical design and careful supervision during the installing and operating of the plant can do more to reduce working costs and to increase safety than skilled electrical knowledge. Great importance is attached to the mechanical construction of apparatus for underground use. Much more attention is now being given to the engineering side of an electrical engineer's training, and there is noticeable a corresponding improvement in the mechanical construction of electrical apparatus for use underground. Even to-day, however, there is still room for improvement, particularly in connection with auxiliary apparatus, including switch and joint boxes, controllers, and so on. Moreover, it cannot be too strongly emphasized that everything, from the main switches to the motor, including all cables and switch gear, should be as far as possible metal-cased with a material impossible of attack from conditions prevailing in mines.

The rules proposed by the committee may be divided into two classes, inasmuch as they deal on the one hand with the design and maintenance of the apparatus and the competency of the person in charge. To take the latter first; it is to be regretted that division of responsibility has not been avoided. The proposed substitute for Rule II, requiring the presence in the mine of a "competent" person, specifies that the "electrician," together with the necessary assistant, shall be appointed in writing by the manager, and shall "be competent for the work that he is set to do." Nobody except such an authorized person or a competent person acting under his immediate supervision is to undertake any work where technical knowledge or experience is required in order to avoid danger. The committee state, however, that the "electrician" is necessarily under the orders of the mine manager, who is also finally responsible under the Coal Mines Regulation Act, and suggest that the examination for a colliery manager's certificate should require a more extensive knowledge of electrical work than it does at present. They consider, for example, that the manager should know a good cable joint from a bad one, and that he should be able to criticise intelligently the maintenance of the electrical plant.

With regard to the choice of system, the committee consider that an alternating current system using high pressure for transmission, high or medium pressures for large motors and low pressures for small motors and lighting, is safer, more reliable, and probably cheaper to install than a system with medium pressure throughout.

Several new rules in connection with earthing and insulation are proposed. Whereas earthing is now specified only in the case of cable sheaths and armourings other than trailing cables, switch cases and motor frames other than portable motors, and then only when the pressures exceed 250 volts, a new rule covers all apparatus at pressures above 250 volts direct current and 125 volts alternating current, including trailing cables, joint boxes, instrument covers, all lampholders unless protected by a fireproof insulating material, and all machines, including portable motors. It is further specified that they shall be earthed by connection to an earthing system at the surface of the mine, and that all earth conductors, other than the metallic covering of cables, shall have a conductivity at all parts and at all joints at least equal to that of the largest conductor supplying the apparatus it is desired to earth. In the case of cables the metallic covering is to have a conductivity at least equal to 50 per cent. of that of the largest conductor of the cable.

The earthing of the neutral point on a three-phase system and the mid-voltage point of any other system both at one point only is permitted as before, but the rule which proposes to make it compulsory to cut off pressure automatically in the event of a fault or leakage will entail considerable alterations to existing switchgear if adopted. High pressures are limited to stationary machines of over 20 horse-power.

Switchgear is to be constructed so that the lodgment of dirt or coal dust on or close to live parts is prevented. The new rules prescribe that switchgear for cutting off the supply shall be provided at the surface within 200 yards of the pithead. In a concentric system the switchgear must be arranged so that the continuity of the earthed outer is never broken. With regard to cables, the proposed rules provide that all multicore or concentric cables, other than flexible trailing cables, shall have a metallic sheath where the pressure exceeds 250 volts. Single-core cables need not have this sheath, but must either be inclosed in a pipe containing all the conductors of a circuit or must be secured to insulators by readily breakable material. All sheathing and armouring is, of course, to be electrically continuous throughout, and is to be earthed with the earthing system by a connection of not less conductivity than the same length of the armouring. The sheathing is to be protected against corrosion where necessary. Flexible cables for portable apparatus are to be multiple-core, and, if armoured, the armouring is not to be the only earth conductor, but an additional earth wire is to be provided.

Coming now to the use of high pressures, the committee suggest that it is better to transform down for motors of 50 horse-power and under when the supply is at 3,000 volts, and if the supply is at a higher pressure it is recommended to transform down for motors of 100 horse-power or less. Small lighting transformers may be run in solid with insulating compounds, while large transformers should be oil-immersed. The secondary circuits should be earthed at one point to avoid the risk of the pressure rising to a high value by contact with the primary. Where this is undesirable, as in local lighting circuits, an earth shield between the windings is recommended. It is stated that the construction of the switchgear should be dust-proof, moisture-proof, and so designed as to prevent open sparking, but no mention is made of the possibility of securing flame-proof protection. Gas-tight construction is not insisted upon, but to insure that there is no open sparking in the event of a fault in the cable it is recommended that the metallic sheath nearest the conductors should be air-tight, as in a lead sheath, or should be enclosed by another sheath, as when armouring is put over an inner copper sheath with a moderately thick bedding of jute or other material between. In both cases the object is to prevent the arc from penetrating to the outside of the cable before the current is cut off. Wire armouring is preferable to tape armouring, and double to single armouring. It is suggested that the ends of the armoured cable should be finished off by securing the armouring to a spigot or to a gland screwed into the switchbox or cable dividing box. Cable boxes should be supported on a brickwork base in a recess by the roadside, and binding of the metallic sheaths inside or outside the box is necessary. It is recommended that a plug should make the earth connection before the supply connection, but though it is stated that the current should not be on when the plug is being inserted or withdrawn the use of plugs and sockets automatically interlocked is not referred to.

Special precautions are suggested where inflammable gas may occur. These refer in the first place to the use of motors, cables, apparatus and signaling instruments especially constructed to obviate the risk of "open sparking." The current is to be switched off immediately sparking occurs or while examination or adjustment disclosing parts liable to spark is being made. In the second place, every lamp is to be inclosed in an air-tight fitting with an hermetically-sealed globe. A safety lamp is to be provided near each motor, and should any indication of fire-damp be given, the attendant must switch off the current and report the matter. The rule relating to shot firing prohibits the use of current from lighting power circuits for this purpose in any circumstances. Haulage by electric locomotives on the overhead trolley wire system is, according to the proposed rules, prohibited in any part of a coal mine, but storage-battery locomotives may be used, subject to the consent of the Home Secretary.

A point on which it would have been an advantage to have had more detailed ruling has reference to lighting circuits mentioned before. There is a paragraph in the report of the committee which states that there is no reason why 100 volts should ever be exceeded on any new underground lighting installation, but, unfortunately, this has not been embodied in the rules. There is certainly no reason why 100 volts should ever be exceeded, but the only way to insure this is to specify that it shall not be exceeded. A rule on this point could hardly apply to direct-current installations, but there is no reason why greater safety should not be secured in some mines because it cannot be secured at all. Further, as alternating-current working is making much greater headway than direct current, the effect of such a rule, if it were also made to apply to existing installations after a reasonable period, would in a few years have spread to the more important part of the mine-lighting installations in Great Britain.

There are a few other points of detail in the report and rules to which attention might be drawn, but we must leave them for the moment. One of the main objects of the committee, apparently, has been to avoid legislating on points of detail, especially as regards construction, rather than lay down general principles which, while not hampering individual design and initiative, are at the same time likely to result in satisfactory detail work. This is an admirable intention; none the less, in view of the peculiar conditions of colliery electrical engineering, there are some points on which we should have welcomed a more definite ruling.

Whatever else the new rules may do, however, they will certainly lead to a great extension of the use of electricity in up-to-date and well-managed pits, although they may somewhat retard its adoption in a few pits where the pecuniary consideration is the deciding one.

# THE STABILITY OF SHIPS

By B. C. Laws, B. Sc., A. M. I. C. E., M. I. N. A.

STABILITY is the one factor contributing to safety and comfort and upon it to a very large extent will depend the pecuniary success or otherwise of the passenger vessel. It is determined not only by the outward form given to the vessel, but also by the amount and the manner of distribution of the weights which collectively contribute to the finished structure, equipment and general loading. These latter obviously will govern and determine the position of the centre of gravity of the ship and its freight, and any change in the amount or distribution of the several items of weight must naturally have its influence on the centre of gravity, and will, in consequence, affect the stability. If weights already on board be altered in position the position of the centre of gravity will probably change, whereas if weights be added to or taken away from the vessel, not only is the position of the centre of gravity likely to be altered, but there results at once an increase or decrease respectively in the displacement and draught, with a consequent effect possibly detrimental, possibly otherwise, to the stability value of the vessel.

It is clear, therefore, that such varying quantities as fuel, stores and service water will continuously affect the stability, not only by their direct influence on the common centre of gravity but also from the resulting change in the displacement and buoyancy of the vessel. As the fuel and stores are consumed the centre of gravity alters its position, while the displacement, and with it the area and moment of inertia of the area of water plane, changes; all of these are contributory items to the vessel's stability, so that whatever the value of the latter may be at the time a vessel is prepared and ready for a voyage it will be modified as she makes her passage between ports.

Every class of steamer, whether warship, passenger vessel, or cargo tramp, will be affected in this way. Further, the tramp, unlike the warship and the vessel designed purely for passenger service, will be subjected to the greatest changes in those variable elements affecting stability, for the reason that she is likely to discharge her cargo and ship another of quite a different character and specific gravity at her port of call, the result of which is generally to bring about a considerable modification in the position of the common centre of gravity of the vessel. It is, therefore, quite evident that a cargo carrier necessitates very careful consideration on the part of the designer in order that she may be rendered stable and safe under the various conditions of loading which she may assume.

It is not the object of this article to discuss the fundamental principles upon which the stability of a floating body is founded. By what has been said already it will have been gathered that the position of the centre of gravity, weight of vessel, displacement, the centre of buoyancy and the water plane area are the important factors affecting stability.

The relative position of the centre of gravity—a fixed point for any one definite condition of loading—and the centre of buoyancy determines for the upright position of the vessel the "initial stability."

Referring to the figures 1 and 2, which show the vessel floating respectively in the upright and in a

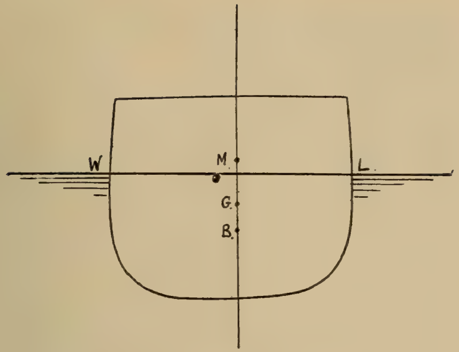


FIG. 1.—UPRIGHT POSITION

slightly-inclined position, let G and B denote the centres of gravity and buoyancy respectively for the normal position and $B_1$ the centre of buoyancy when the vessel becomes inclined. The buoyancy—equal in value to the weight (W) of the vessel—acting upwards through $B_1$ intersects the middle line plane in M—the metacentre. The distance between G and M is the "initial stability" or "metacentric height" of the vessel. It is obvious that M is dependent upon the position of B (i. e., of $B_1$) and the value of G M, therefore, on the relative positions of G and B.

M is practically a fixed point for small inclinations up to 8 or 9 degrees, but beyond this its position varies. It can easily be proved that the value of B M is equal to "the moment of inertia of water plane area" divided by "the volume of displacement of the vessel," where the moment of inertia is taken about a transverse axis through the centre of area or gravity of the water plane.

In this way we are able to determine the value of G M, and for small inclinations ($\theta$) the righting arm or lever $Gz = GM \sin \theta$. It is this righting arm, together with the equal and opposite (vertical) forces W acting at its ends, which constitute the mechanical couple tending to bring the vessel again into the upright position after being inclined through the agency of external forces, such as wind or the action of waves.

For angles greater than 8 or 9 degrees the value of $Gz$ may be calculated from the lines of the vessel, and if this is done at certain angular intervals, say of 10 degrees, we may construct a curve of righting arms to a base of angles of inclination. This is the statical stability curve, the use of which is, that by its aid we are able to determine the righting arm or righting moment for any particular angle of inclination required, other than those from which the curve has been constructed.

Fig. 3 represents such a curve, and the value of the righting arm for any angle of inclination $\theta$ is determined by setting off the angle ($\theta$) along the base line and measuring the ordinate ($r$) of the curve at this point.

If W be the displacement for that condition of the vessel to which the curve has been constructed, then $W \times r$ gives the righting moment at the angle of inclination $\theta$.

Such curves are usually constructed for certain and specific water lines to which the vessel is likely to be loaded, generally assuming a homogeneous cargo in each case. Any departure which may be made from homogeneity—as, for example, in the case of a general cargo—can easily be allowed for in determining the effect upon the position of the centre of gravity and therefore on the value of the righting arm.

It is always necessary in the case of a vessel having little cargo and consequently being compelled to resort to

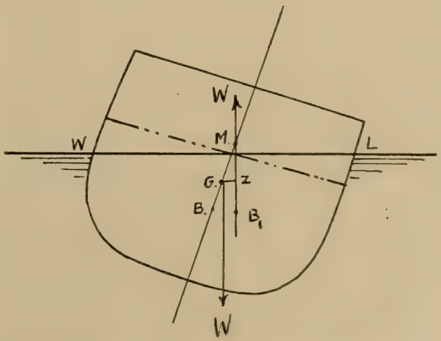


FIG. 2.—SLIGHTLY INCLINED POSITION

the use of water ballast to see that such ballast completely fills the tanks holding it; it is a *sine qua non* that all water compartments or other spaces used for the carrying of liquid cargoes must be either completely empty or quite full.

The problem of stability is at once simplified where a vessel from the nature of her service will experience little variation in displacement and draught; such examples are found in the case of warships and yachts, in which the condition of the vessel is practically unalterable, except in so far as the consumption of stores and fuel will bring about a comparatively *slight* modification in displacement and the position of the vessel's centre of gravity.

The cargo vessel presents a much more complex problem on account of the considerable variation in loading which from time to time she may experience.

On one voyage the cargo might be such as comfortably to fill the holds, the vessel floating at a suitable draught with a moderate amount of initial stability; at another time the cargo might consist of material of high specific gravity so that the holds may not be nearly filled; in such a case if the cargo were stowed low down there would result a considerable and undesirable increase in value of the initial stability. Under such circumstances it is wise to distribute the cargo—a portion being stowed high up in the 'tween decks in order to raise the position of the centre of gravity and, consequently, to moderate the amount of initial stability. Yet another case might arise in which the cargo may be so light or so small in amount as to necessitate resorting to the use of ballast in order to cause the vessel to float at a reasonable draught with the propellers sufficiently immersed. Such ballast usually consists of water carried in the double bottom, and is such that a considerable increase of metacentric height results without there being any means to prevent it. Vessels under such conditions when meeting rough weather at sea are very uncomfortable, to say nothing of being subjected to severe straining action.

Turning from cargo carriers to those vessels primarily designed for the carrying of passengers almost to the absolute exclusion of cargo space, except perhaps sufficient for the stowage of baggage, new conditions are presented to us which necessitate careful consideration. In this class of vessel, designed for swift passage, the machinery and fuel or bunker space occupies most of the volume which ordinarily would be devoted to the stowage of cargo; above this is the passenger accommodation, with its attendant heavy fittings, confined perhaps to the 'tween decks or extending higher, according to the number and class of passengers to be carried.

With the best class of vessel in recent years there has been a tendency, which has rapidly grown, to build the accommodation for passengers as high in the ship as possible. This tendency has been not altogether the work of the designer, nor has it been his desire to increase, often to excessive proportions, the height of the above-water portion of the vessel. Rather it has been forced upon him by the exigencies of the situation which have arisen from the desire of passengers to secure accommodation high up in the ship; if there be a promenade deck built in the vessel for his special benefit he prefers there were another higher up, and even so, he likes occasionally to mount to the bridge or flying bridge if he may be privileged to do so. The explanation is that greater facility and convenience is afforded and better ventilation obtained at these higher positions than lower down in the comparatively confined 'tween decks.

The uninitiated mind of the casual observer sees great danger in the growth of the superstructure. The vessel is assumed to be top heavy and, if not actually unstable, as possessing little margin of safety for sea-

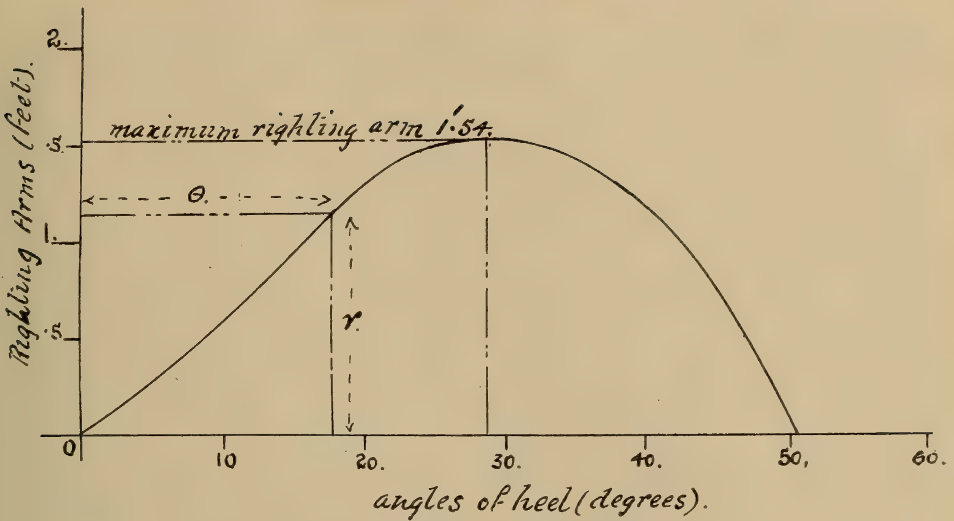


FIG. 3.—STATICAL STABILITY CURVE

going purposes. Such fallacious impressions find ground in the fact that the ordinary individual is not in a position to form an accurate judgment of all the conditions; he is unable to take into consideration the fact that the form of the under-water (out of view) portion of the vessel, the primary factor governing stability, and the lines of the vessel generally have been so molded as to meet all the demands for safety and efficiency.

It is quite possible that a vessel of this type would actually possess greater stability than another vessel of less bulky appearance above water, but which to the ordinary observer would probably be preferred to the vessel of the prominent superstructure.

A vessel possessing top hamper is not necessarily unsafe any more than a vessel of ordinary type possessing the regulation upper and bridge decks would be necessarily stable. Stability, indeed, depends upon a variety of factors. The position of the centre of gravity, a fixed point for any given condition, that of the centre of buoyancy (a point the position of which is variable with draught and inclination), the weight and general dimensions of the vessel, and, related to this latter, freeboard and beam, are all very important factors affecting stability.

The stability depends on all these factors taken collectively and not upon any one isolated feature of the design.

The true measure of the stability of a vessel for any given inclination from the upright is "righting moment"—that is, the product of "weight of vessels" and "righting arm" and not merely the value of the "initial stability" or metacentric height, which in any case is only applicable for angles of inclination less than 10 degrees and is chiefly of service in indicating the quality of "stiffness" possessed by the vessel.

Under any specific conditions of loading, in which the weight or displacement is constant, righting arms may be used in lieu of righting moments, and this is generally done in calculating stability and drawing the curves relating thereto. It does not follow that the same vessel, which under separate conditions of loading may float at the same draught and therefore at the same displacement, would be equally comfortable at sea or equally safe although possessing the same amount of stability. This latter may be brought about by various methods of loading with heavy or light cargoes, but the behaviour of the vessel at sea will depend, not altogether on the stability value, but additionally upon the manner in which the weights which go to make up the displacement are distributed in the vessel.

Were the weights winged or generally distributed away from the centre of gravity the result would be an increase in the value of the radius of gyration of the vessel, as compared with a more concentrated position of those weights about the common centre of gravity, and in consequence the period of roll or time taken by the vessel to swing from side to side would be affected. From a well-known principle in rigid dynamics we know that the mechanical moment of the accelerating forces at an instant involves the product of the moment of inertia of the oscillating body and the angular acceleration; therefore, assuming the external forces causing motion to remain unchanged, the angular acceleration will diminish, i. e., the rolling motion will be slower with an increase in moment of inertia, and vice versa, provided the centre of gravity of the vessel remains unaltered.

But suppose the position of the centre of gravity has changed, this would probably produce an alteration in the initial stability of the vessel, affecting the period or time of roll, inasmuch as the latter depends on the square root of the initial stability inversely.

It is unnecessary in this article to pursue the mathematical aspect of the subject, but it will be seen from what has been stated already how the rolling motion will be affected according to the manner with which the weights are distributed in the vessel. It is on this account where vessels having a small amount of cargo on board, or even no cargo at all, have to proceed to sea in ballast, in order to properly immerse them and their propellers, that wing tanks, Fig. 4, are preferable to double-bottom tanks, as producing less effect on stability, while the effect on the moment of inertia would not be widely different, dependent, of course, on the weight of water ballast and the position occupied by its centre of gravity.

A similar feature is observed in the case of war vessels, which, due to the nature of their service, are required to carry heavy weights in the shape of armour plating at their sides and barbettes or turrets, and mounted with heavy guns on deck, Fig. 5. Such weights, due to their situation relative to the axis of rotation, will have a tendency, on account of the angular velocity acquired when rolling has once commenced, to increase the angle of roll.

Just inasmuch as the stability and the behaviour of the vessel at sea will be largely determined by the loading and the manner of the distribution of the various items of weight contributing to the lading, so on the other hand will the stability be favourably or unfavourably affected according to the change which may be made in the dimensions and form of the vessel; meaning by form, not only the shape of that part of the body which when she is floating upright is submerged, but also the portion of the body contributing to the reserve buoyancy usually above water but which, due to rolling, might be submerged. It is this part of the structure which plays such an im-

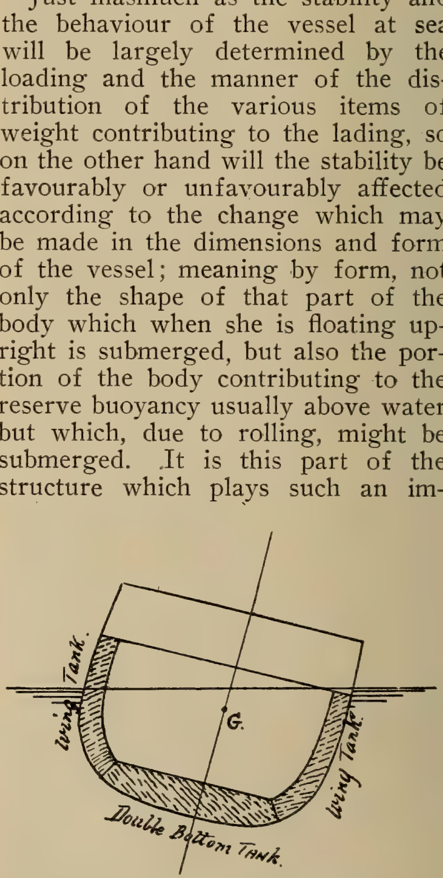


FIG. 4.—WING TANKS

portant part in determining the righting power and range of stability when the vessel becomes appreciably inclined from the upright position of equilibrium.

The ordinary calculations relating to initial stability take note only of the vessel for the upright position, and hence the above-water portion of the vessel does not enter into the calculation, except in so far as it affects the position of the centre of gravity. It is only when we come to estimate the statical stability for possible appreciable and considerable angles of heel that account is taken of the *above-water* portion of the body.

It is customary for most shipbuilding establishments to make an estimate of the initial stability or "G M" of the vessel for various assumed conditions of loading. The method is to calculate the position of the metacentre relative to the centre of buoyancy, and, knowing the height of central buoyancy above bottom of keel, a curve may be constructed showing the height of metacentre above bottom of keel. The position of the centre of gravity of the vessel and its load for the several assumed water lines is estimated and marked on the diagram, so that the value of "G M" for the several conditions are at once determined. This is the "metacentric diagram," an example of which is shown in Fig. 6 for a cross Channel high-speed paddle steamer.

Since the height of metacentre above centre of buoyancy is determined by dividing the transverse moment of inertia of water plane area by the volume of displacement, it may be represented by $C\frac{B^2}{D}$, where $C$ is a coefficient, depending on the type of ship, B the breadth or beam and D the draught. Also the height of centre of buoyancy above the bottom of keel may be similarly represented by $k$ D, where $k$ is a coefficient, and combining these two expressions into one formula we may approximately determine the height of metacentre above the bottom of keel amidship from the expression:

$$C\frac{B^2}{D}+k\,D=\frac{36D^2+5B^2}{64D}\quad\text{or}$$

$$=\frac{9}{16}D+\frac{5}{64}\,\frac{B^2}{D}$$

This expression, where the metacentric diagram is not immediately to hand, is useful in estimating *roughly* the initial stability of a vessel when the position of the centre of gravity is known.

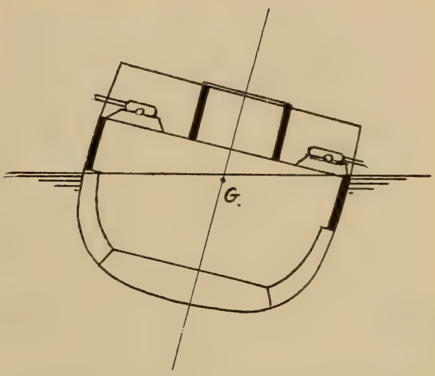


FIG. 5.—ACTION OF ARMOUR AND GUNS

It is evident that draught and beam are important factors governing the position of the metacentre. For a given draught the height of metacentre is increased with increase of beam, and vice versa, and if the breadth of vessel be preserved the height of metacentre will increase or decrease with a variation of draught, according to the relative variation of the two terms in the expression.

Generally in beamy vessels an increase of draught would bring the metacentre down, whereas in narrow vessels the height of metacentre would increase.

It is for this reason that where the designer is restricted to a limited draught he has to fall back upon a modification of the beam of the vessel in order to obtain a satisfactory position of the metacentre. By such means he is able to get any desired metacentric height, but experience teaches him not to exceed a certain maximum, while the condition of service by which the vessel may be required to negotiate certain channels, canals, or dock entrances would restrict him to a maximum beam. The great point is for a vessel to possess a sufficient, but not an exaggerated, amount of initial stability, for the reason that she would otherwise acquire "stiffness," resulting in quick or heavy rolling and discomfort to passengers when encountering weather or waves at sea, whereas a more moderate amount of stability would be productive of greater comfort, though the vessel would take longer to complete her rolling motion, with possibly a greater angle of roll.

The latter type of vessel, possessed of sufficient stability and an easy motion, is much to be preferred to the stiff ship with the jerky, heavy rolling, although passengers with experience of such a vessel, though they may be alarmed at her behaviour, have always the satisfaction of knowing that she is amply, if not *too safe,* from the point of view of stability.

The question arises then as to what would be a reasonable amount of metacentric height to assign to a vessel. The answer is that there is no standard which can be set up. Each class or type of vessel must be taken on its merits and just such an amount should be assigned as the teaching of experience dictates. Strictly speaking, ten to twelve inches in big passenger vessels to as much as three feet in small vessels are met with in practice, and this in order to preserve the balance of righting power or moment when the vessel becomes inclined, for with the smaller vessel the acting righting forces, viz., the weight of bouyancy, being considerably reduced, the righting arm, which for small angles of inclination depends on the metacentric height, must be increased in order to preserve sufficient righting moment. The same argument holds for inclinations greater than 8 degrees or 9 degrees, i. e., for those inclinations to which we can no longer apply or use the metacentric height for purposes of stability calculations.

Up to 8 or 9 degrees the righting arm may be said to vary directly with the angle of inclination, but beyond this the variation in value of righting arm will be greater than that of the angle of inclination; in other words, from about 8 degrees the statical stability curve will be much steeper until a point is reached at which the maximum arm is registered and beyond which the curve falls again until it intersects the base line at a point indicating the range of stability, see Fig. 3. If this angle or range were exceeded, the vessel becoming unstable would inevitably capsize. Cases are known where disaster has occurred from this cause, but vessels are now so designed that there is the absolute minimum of risk in this respect. Vessels experiencing the most severe weather conditions seldom exceed an angle of inclination of 20 degrees on either side, whereas the stability would, in most cases, become *nil* only after an angle generally exceeding this by two or three times—at least—had been reached.

Before such a limiting angle could be reached, however, the probability is that a vessel would founder from other causes, such as the shifting of cargo or weights on board or through large volumes of water finding ingress through skylights or openings in the deck not absolutely closed.

Reference has been made to the effect on stability of cargoes, such as grain, coal, oil, carried in bulk, etc., and of water ballast. Too great care cannot be taken in the disposal of such elements of freight, due to their tendency to shift or to geometrical character of their exposed surface to alter as the vessel rolls. Where large areas of such surface exist there is always an element of danger, and this applies more especially to liquids, on account of the immediate and continual change in the form of its surface as the vessel inclines. With

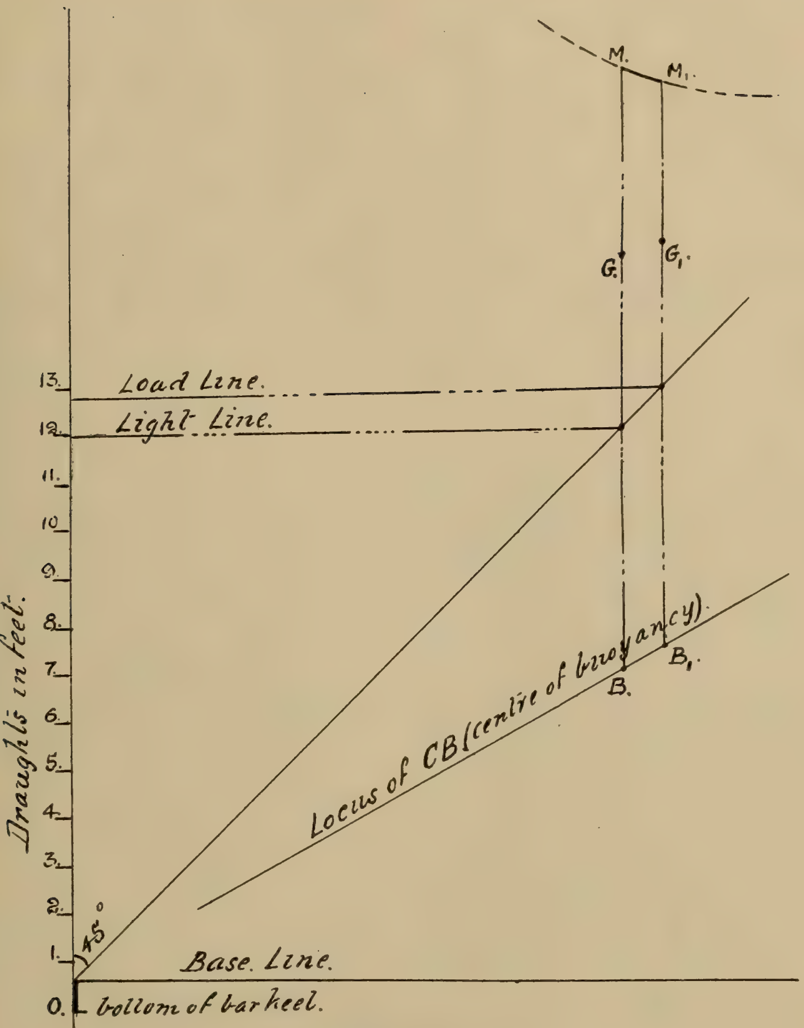


FIG. 6.—METACENTRIC DIAGRAM

grain or coal the surface will not change until such an angle of inclination is reached corresponding to the angle of repose of the mobile cargo, after which the particles at the surface will slide over each other, tending to heap themselves up on that side towards the direction of rolling.

The consideration of this free or exposed surface is, therefore, one of great importance as affecting the well being of the ship, but the resultant effect of a change of surface is not so much due to the quantity or weight of the mass moved as to the extent of change of surface.

It has been seen that the value of B M or the distance between the centre of buoyancy and the metacentre depended on the moment of inertia of water plane area *directly* and the volume of displaced water *inversely*, and was represented by the expression $C\frac{B^2}{D}$. So in a similar manner, —Fig. 7—with regard to a fluid or mobile cargo, the point of intersec-

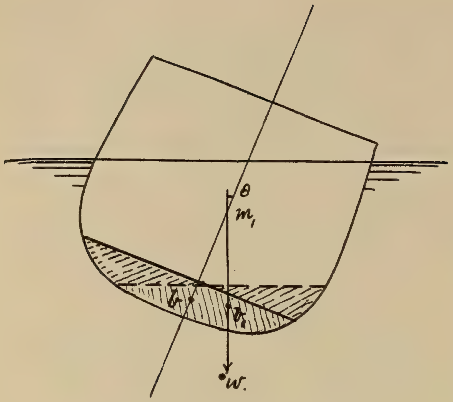


FIG. 7.—ACTION OF MOBILE CARGO

tion of the line of action of its weight for any small angle of inclination, with the initial line of action will be situated above the centre of gravity of the fluid body at a distance given by a similar expression, $C_1 \frac{B^2}{D_1}$ where $B_1$ is now the breadth of the free fluid surface and $D_1$ the depth of the fluid, i. e., this distance will be chiefly governed by the breadth squared of the free water surface, and the greater the variation in this height, the greater will be the lateral movement of the line of action of the weight of the fluid body, and as the force acts in the downward direction, this lateral movement always sets up a tendency to reduce the righting power of the vessel, hence reducing the breadth of the moving surface, or in other words curtailing the lateral movement of the fluid is tantamount to minimizing this upsetting tendency.

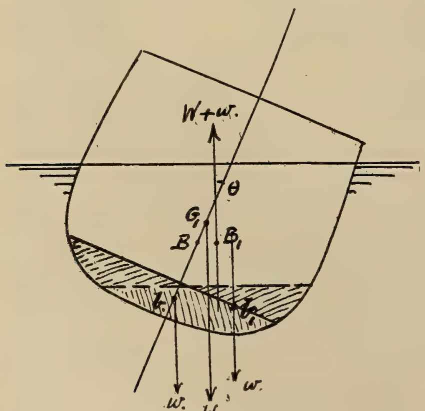


FIG. 8.—MOVEMENT OF FLUID CARGO

This perhaps may be more clearly shown by considering Fig. 8, in which $w$ is the weight of the contained fluid and $b$ its centre of gravity; W is the weight and $G_1$ the centre of gravity of the vessel, less the contained fluid. If the vessel becomes inclined to an angle $\theta$ so that $b$ is now shifted to $b_1$, it will be seen that the movement of $w$ might be such that $b_1$ is situated to the right of $B_1$, the centre of buoyancy of the vessel, and in consequence will set up a moment relative to $B_1$, tending to upset the vessel.

It is on this account that we generally find in double bottom tanks, utilised for the carrying of water ballast, a middle line watertight division so that the breadth of free water surface is at once reduced by 50 percent, and the lateral movement of the free fluid is curtailed, the longitudinals between the middle line and the tank sides, though not usually watertight, further split up the free surface and confine—even temporarily—the water within still narrower lateral limits.

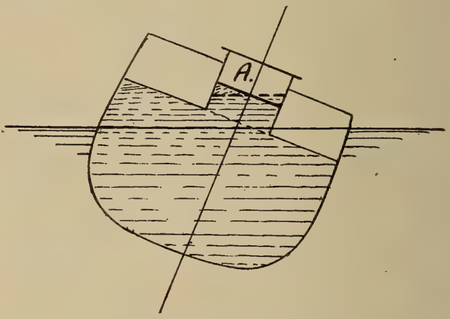


FIG. 9.—EXPANSION TRUNK

The same principle is carried out in vessels designed for carrying oil in bulk. An "expansion trunk" A—Fig. 9—surmounts the compartment and serves the dual purpose of allowing the fluid to expand with increase of temperature, and also limiting the freedom of lateral movement of the fluid surface.

# THE REDUCTION OF POWER LOSSES

By Karl W. Knorr

EVERY factory owner or manager wants to manufacture his output with the least possible cost, while at the same time keeping the product up to the proper standard of quality and workmanship. In order to do this it is very essential that the amount of power required to operate the plant be kept down to a minimum, for every horse-power developed means a certain quantity of coal consumed, and coal consumption means expense.

Lost power is a large factor in the operating expense of every plant, and the live, up-to-date manager or owner is continually on the lookout for ways and means of eliminating waste of this character, which usually begins in the boiler room and ends only at the machines in the remotest part of the factory.

There is usually waste at the very start in firing the boilers. Injudicious and careless firing is among the greatest sources of lost energy in any plant. There is just as much need for study and skill in the firing of a boiler as there is in the running of the engine or the operating of the most complicated machine in the mill. If the boiler is improperly or carelessly fired the coal will burn without making the hot fire which is necessary to produce steam.

Many people have had the experience of wondering how their neighbors, whose houses and heating equipment are almost, if not exactly, like their own, are able to keep their houses comfortable and at the same time burn so much less coal than they themselves use. And all the time they are wondering they are saying to themselves way down in their hearts that the neighbor knows how to manage a furnace better than they do.

There is the whole thing in a nutshell; and if the saving in heating a house for a season, in which the total consumption of coal may not run over 12 tons, will amount to a ton or even only a half a ton, the possibilities of saving fuel in plants using hundreds of thousands of tons a year can be easily imagined.

The remedy for this is evident. It may not be possible to correct the trouble entirely, as the personal equation enters largely into it, but it can be materially improved by studying firing methods and securing firemen who can carry them out intelligently.

A single high-grade fireman is worth a half dozen incompetent ones, and it pays to get the high-grade men, even though they must be paid high wages. They are an investment which returns big dividends.

Another cause of lost energy is the use of boilers of poor design and construction. No matter how carefully the firing is done, proper returns, in the shape of steam for the coal consumed, cannot be obtained, for the plain and simple reason that the boilers are inefficient.

The way to eliminate this loss is evident. The testing of a boiler is not an expensive proposition, and it is worth while to have it done, for it does not take long for the cost of the energy lost through the use of inefficient boilers to equal the cost of new ones.

If the water fed to a boiler is hard it will be found that in a very short time scale will begin to form in the boiler, the rapidity and thickness of the formation depending upon the character of the water. This scale is not a good conductor of heat, and as it forms on the boiler tubes the heat has to pass through the scale before it can get to the water. As a result a large percentage of the heat is lost, which, but for the scale formation, would be absorbed by the water, thus producing steam.

No matter what kind of a boiler is used there is bound to be scale if hard water is fed into it, and if there is scale there is bound to be a material loss of energy.

The remedy for this is obviously to feed soft water to the boilers, so that wherever the water is hard a water-softening apparatus is just as essential in a well-designed plant as the boilers themselves.

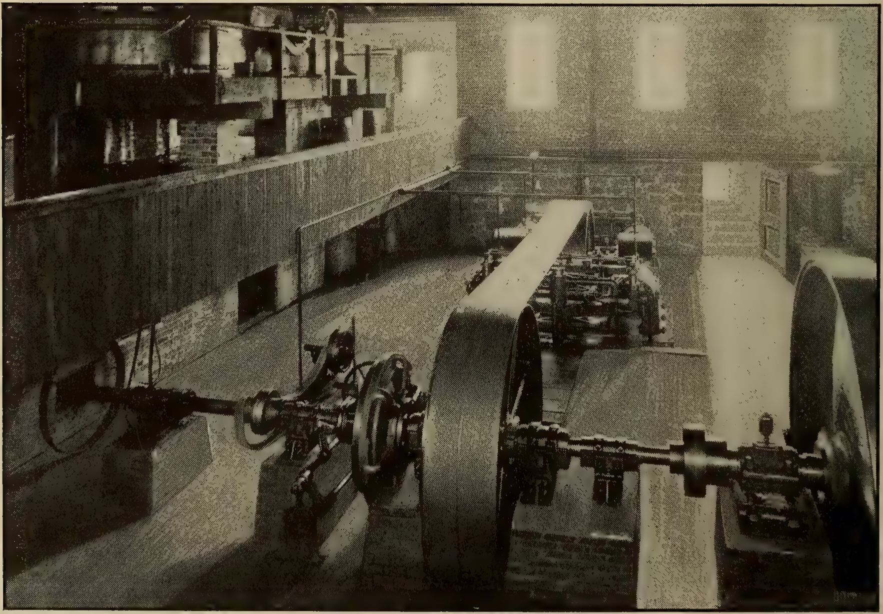
The continuous type of water softener is the most efficient and requires the least attention, so it is, consequently, the best investment.

Poorly-arranged piping from the boilers to the engine will produce further loss, for in cases of this kind a large portion of the steam is cooled sufficiently to turn it back into the water before it gets to the engine. Of course, the expense of making steam so lost brings no returns and is money thrown away.

Losses of this character can be corrected by properly rearranging the piping and covering it with a jacket suitable for the conditions, so that heat will be retained.

In the engine there is often a great deal of steam wasted, which, of course, means an increase in the expense column.

If the engine is one of poor design, or if its parts are improperly made, it will need more steam to run it than will be required for one of the same rating, but properly designed and constructed. Then, too, if the valves are improperly set the amount of power developed in the engine will be far less than what it should be for the amount of steam delivered to it. Also, if the engine is being overloaded it is not working economically, for in order to pull the load it must take steam from boilers for a greater portion of the



QUILL INSTALLATION IN PAPER MILL SHAFT EXTENDING THROUGH QUILL IS RUNNING AT FULL SPEED, WHILE QUILL IS STANDING STILL.

stroke than would be necessary if the engine were working within the amount of power it was designed to develop. As a result, it is impossible to take proper advantage of the expansion of the steam and, consequently, more steam is used than would be required to operate an engine designed for the actual load being carried. Of course, more steam means more expense.

The methods of overcoming these losses are clearly the substitution of a first-class engine for the one of low efficiency, or the proper setting of the valves where the valves are at fault. When an engine is overloaded the losses may be relieved in several ways, but which one should be adopted depends entirely upon the conditions surrounding the particular proposition under consideration.

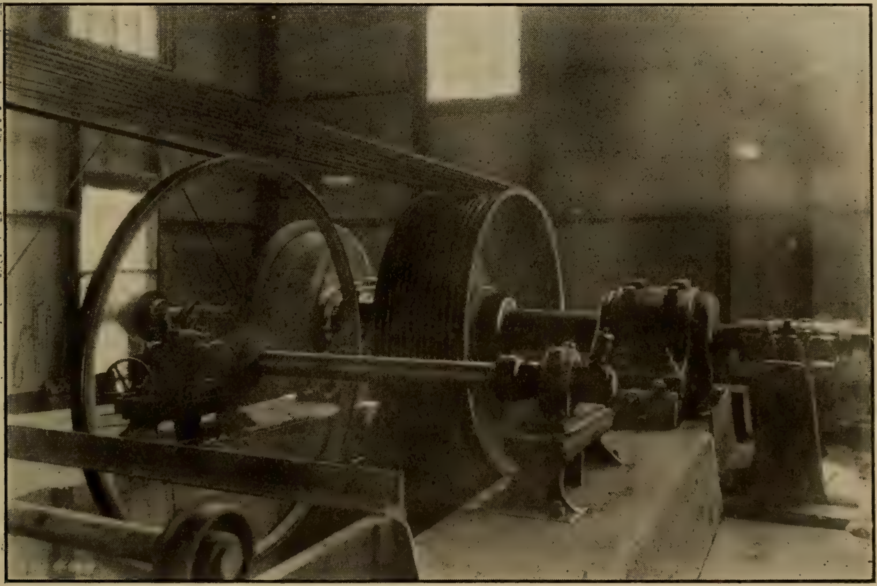
An increase in the boiler pressure or the installation of a condenser, if the engine is not already running, condensing, will increase the capacity of the engine without reducing its efficiency. A condenser, however, requires a considerable water supply and sometimes this is either not available or only so at a cost which more than offsets the saving produced by the condenser.

Running the engine at a higher speed will make it possible to develop more power without overloading, and it is frequently desirable to combine this with the installation of a condenser.

It may prove advisable to install a second engine to work with and help out the one being overloaded; or perhaps it will be found that the best thing to do will be to replace the overloaded engine with a new one, designed to carry the load it will be required to pull.

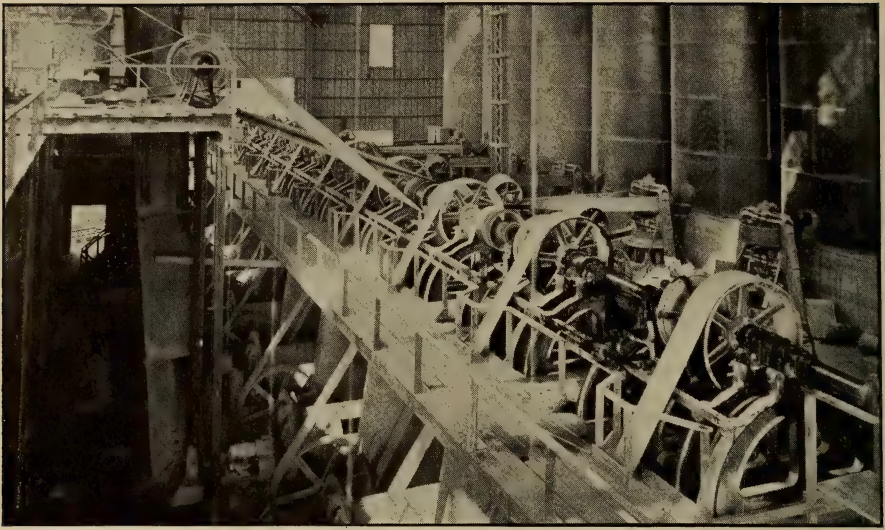
With the distribution of the power from the engine to the various points throughout the plant the losses in power transmission commence, and they will be large or small, depending upon the quality of the equipment and its arrangement.

The reduction of power losses is a broad problem and one in which



SHEAVE, RECEIVING POWER FROM MAIN ENGINE, CARRIED ON QUILL.

Note heavy bearings required by load carried and comparatively light bearings supporting shaft going through quill.



MINIMIZING FRICTION IN CEMENT PLANT.

Long line of shaft driving tube and Griffin Mills. Tube mill drive pulleys are mounted on quills connected with shaft by clutches.

should be sought the advice of those who have specialized in the subject and whose experience is consequently broad and comprehensive. If this is done it will be found possible to eliminate a great portion of the leaks and, as a direct result, materially cut down the cost of operating the plant without in any way reducing its output.

The design of a power transmission equipment consists of much more than simply picking out shafting and pulleys of proper sizes and putting bearings wherever they can be conveniently located. There is not the slightest question that an equipment laid out along these lines will work, but it is almost certain to be extravagant in the consumption of power.

In a properly-designed installation careful consideration is given, not only to the proportions of the material, but to its arrangement and suitability for the service which will be required of it, and under which it will operate. The peculiarities of the particular service are carefully and thoroughly analyzed, and the equipment is selected and arranged to produce the best results at a minimum operating cost.

Attention has been called to the value of friction clutches and friction-clutch cut-off couplings as reducers of power losses in a factory, and it is the object here to call attention to a device which is usually operated in conjunction with a friction clutch, materially broadening its possibilities, and yet which is not used as much as it should be, undoubtedly for no other reason than that its value and desirability are not generally known.

When a pulley is mounted on a clutch sleeve, which, in turn, is supported on a shaft running through it, the pressure between the sleeve and the shaft is dependent upon the weights of the pulley and sleeve and the pull of the belt. This belt pull is often quite an item, especially in drives carrying large amounts of power, as it is not at all unusual to have a total belt pull, in double belts, of 80 to 100 pounds for each inch in width of belt. In the case of a 24-inch belt this would amount to a ton or more concentrated on a small bearing surface.

With the shaft revolving and the

sleeve and pulley standing still there is bound to be friction between the two, and as the friction increases with the pressure between the two surfaces it will be seen that it is extremely desirable that this pressure be kept as low as possible, or eliminated entirely.

Where the drive carries but a moderate amount of power and, as a consequence, a comparatively narrow belt is used, the friction does not amount to much, but where wide belts are used, carrying large amounts of power, this matter of friction must be given consideration.

To eliminate this loss the quill has been devised. The quill is nothing more or less than a clutch sleeve bored about a quarter of an inch larger than the shaft running through it, to permit about an eighth of an inch clearance between the shaft and quill, and supported in separate bearings of its own.

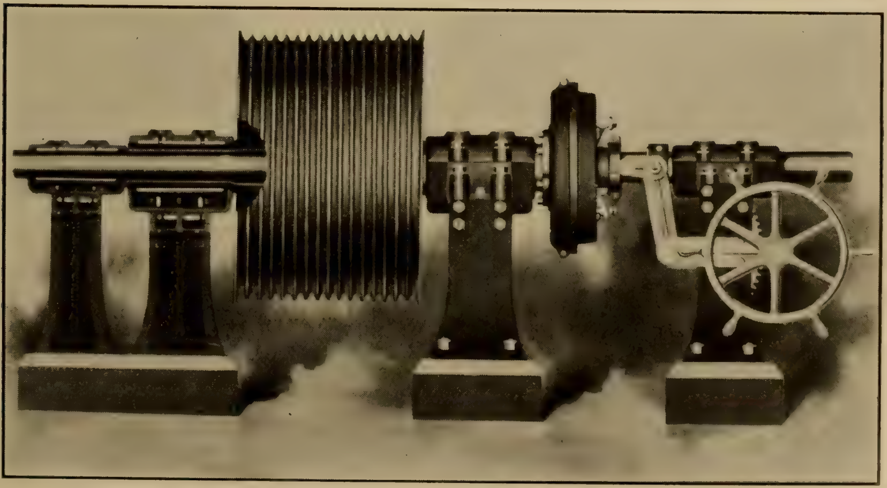
It will be seen immediately that with the shaft running through the quill without contact with it there can be no friction between them, and in addition to this the shaft is relieved of all the side pulls, these being carried in the quill bearings, so consequently does not have to resist any tendencies to bend.

The supporting of the quill in separate bearings of its own makes perfect lubrication possible, which cannot be obtained in the case of a regular clutch sleeve. This is due to the fact that the quill can be supported in self-oiling bearings of most approved design, while the ordinary sleeve is necessarily dependent upon grease cups of some type for its lubrication.

Another point well worth bearing in mind is, that where a clutch sleeve is used it is necessary to use a shaft which is amply large to withstand not only the strains produced by the twisting of the shaft, but also the tendency to bend produced by the belt pull and the pull of the load; but where a quill is used, the shaft being relieved of the load tending to bend it, it is necessary to use a shaft of only sufficient strength to work safely under the twisting strains.

From this it will be seen that in addition to being a means of materially reducing friction losses the quill can be used to take the place of large and expensive shafting, with its accompanying bearings, which would otherwise be required for a heavy drive, permitting the use of comparatively light shafting running through the quill and taking power from it.

If it is not desired to have the quill



QUILL WITH FRICTION CLUTCH.

Note clearance between shaft and quill, eliminating friction. Shaft is relieved of weight of sheave and pull of ropes, which are supported by quill bearings.

fitted with a friction clutch so the power can be instantly thrown out, it can be connected to the shaft either by bolting it to one half of a jaw clutch, the other half of which is keyed to the shaft and slides on it, or bolted to one half of a flange coupling which is keyed on the shaft.

The advantages of the quill outfit over the loose sleeve mounted on the shaft are numerous, including, as they do, the elimination of all friction between the shaft and the sleeve, and perfect lubrication of the bearing portions, while its cost is practically the same as a properly-designed equipment using the loose sleeve running on the shaft.

The difference between the cost of the large shaft and necessary bearings to support it which are required when the quill is not used, and the small shaft and its bearings, the use of which is made possible by the installation of the quill, will practically cover the cost of the quill bearings and the difference between the quill itself and the sleeve.

# THE REQUISITES FOR SUCCESS

By J. Harvey Dew

THAT "there is no such word as failure" is a very old and trite proverb, but it has always seemed to carry with it a serious lack of explanation.

If the declaration were true, then, of course, success would be invariable, but observation and experience in every-day life bring to our knowledge the sad and unfortunate circumstances and conditions which shroud the lives, cloud the prospects, and form or modify the habits and chances in life of many men.

So it is easy to recognize the monumental fact that failure or a meagre success predominates over marked success by "a large majority."

Can this be avoided? Is it possible to guard against or to escape from the evils that lead to failure?

I believe it is not only possible, but certain, barring accidents, when the ordinary rules of true and practical manhood are observed and followed.

That man, individually and collectively, is largely a creature of circumstance, there can be no question, and yet it is not at all contradictory to assert that he is also the chief "architect of his own fortune," certainly of his own personal worth.

The conditions under which we come into existence, our parentage, inheritance and environment—physical, social, educational and financial—have, of course, an immense influence in developing and shaping our destinies.

Over very many of the results brought about directly as a consequence of these conditions, when they are unfavorable, we are entirely unable to gain control, or else, if successful in doing so, it requires years of effort and earnest endeavor to change and turn them to our advantage.

Fortunate indeed is the man born with all the desirable conditions provided for him or who is started in manhood with the "meaner ambitions" of life already gratified—birth, position, social standing, education and wealth: all his to begin with. How very much have we to expect from such a person, how very much more should be accomplished by him in the higher spheres of life and progress!

To possess all these advantages and then to lead a life of indolence, to accomplish nothing for the special good or advancement of the race, is simply to score a failure. And yet this is exactly what a majority of these fortunate ones do.

Necessity, want, and ambition are the three mainsprings which force and stimulate us onward to success, and every individual must possess one or more of these influences in order to do himself credit.

But what is success? It is simply an accomplishment or fulfillment of our aims and purposes to the satisfaction of ourselves and others. It is that which demonstrates in itself the desired returns for honest labor and effort expended. It is that special reward which follows our efforts, intellectually or physically, to attain beneficial or advantageous results for ourselves and our fellow man.

So it is that man who appears to reap the greatest benefit from his individual acts or general efforts in life who is termed and recognized as "the man of success."

Success is measured by degrees, and is largely a comparative expression. There is the widest conceivable range of difference between a very small or meagre success and the immense accomplishments exhibited by success on a large scale.

It is with unbounded admiration and often with wonder that we read or listen to the history and incidents in the lives of eminently successful men, and it is especially interesting to note the chain of circumstances which has led them on, one opportunity or advantage serving to open the way to another.

It is true, indeed, that the man of success is simply the one who sees his opportunities and has the ability to take advantage of them.

Opportunities do not always present themselves in equal size or value, and it is frequently astonishing to see how taking advantage of apparently very insignificant ones will lead to great results, even to the attainment of distinction and reputation or of fame and fortune. Hence one of the secrets of success is never to allow one wave of opportunity to "roll at your feet" without taking full advantage of its presence before it recedes.

It is sometimes amusing to watch the pursuit of a supposed opportunity and to note its termination. It is often like the small boy's chase of a butterfly; after many desperate efforts to capture it he sees the coveted object of his pursuit wing its flight to other and more pleasant fields.

In order to recognize and be able to avail ourselves of the opportunities that may come in our way during life, thorough training in the physical, moral and intellectual requisites for success becomes essential.

This training begins with infancy, and every good parent by one means or another endeavors to so mould the physique and character of the offspring as to form a practical basis for the future.

When manhood is reached this foundation work should have been thoroughly established, and may be termed the preliminary requisites for success.

They may be formulated as follows:

1. A healthy condition of body and mind;
2. A fair education;
3. Honesty and truthfulness;
4. Sobriety;
5. Energy and industry;
6. Economy;
7. Good manners and politeness.

No youth should fail to have this formulation indelibly stamped upon every segment of his brain, and the urgent importance of each and every requisite equally impressed.

This preparatory education is to be acquired at the mother's apron-string, from the teachings and examples of the family, at school, from the pulpit and the rostrum, and in the commingling which desirable social acquaintance affords.

Some parents, especially mothers, are far more proficient in the accomplishment of this preparatory tuition in their children than others. Whenever the education of a family of boys and girls has been completed, and they have turned out well in life, it will almost invariably be found that they possessed a mother of most sterling qualities, whose methods of instruction and discipline have implanted a lasting and determining influence, shaping the character and capacities of her children.

The importance of these cardinal principles of manhood is beyond calculation. By far the greater number of failures in life are directly attributable to a disregard, neglect, or inability to recognize the necessity for a strict observance of some one or more of these essentials.

In the vast majority of failures or of meagre successes in individuals, wherever found, it is necessary only to trace their histories from the beginning of their business careers to find that these declarations are true.

In addition to the preliminary requisites already named, there is still a final group to be enumerated, which form culminating requisites.

Having determined upon a business occupation, whatever it may be, it next becomes essential:

1. To know your business, know it so thoroughly as that no one is more capable in that line than yourself;

2. See to it that each and every detail of that business when entrusted to you is properly executed, that no one can find fault with the work you do; and

3. Please your employer or your client, charging reasonably for what you do.

If the foundation work has been properly laid, and by application, study and industry these last three essentials have been attained and followed, success "will be inevitable" and there will be "no such word as failure."

When the necessities enumerated have been carefully looked over it must be admitted that each and every one of them is easily acquired, and within the grasp of every healthy, intelligent, and well-meaning individual.

It is seldom, if ever, that these principles of manhood and of business life are so formulated and impressed upon those beginning a career as to make them properly feel, understand and appreciate how absolutely essential they are to an honorable success.

There is no doubt but that the earnest desire of each and every young man or woman who has been properly reared is to score a success in his or her respective fields of endeavor.

That the accomplishment of that end takes time, patience, and perseverance must be recognized as unavoidable, but that he who has properly qualified himself and is ever watchful of his opportunities, never tiring in his constant efforts, and honorable in all his dealings, will surely be rewarded with unquestioned success there can be no doubt.

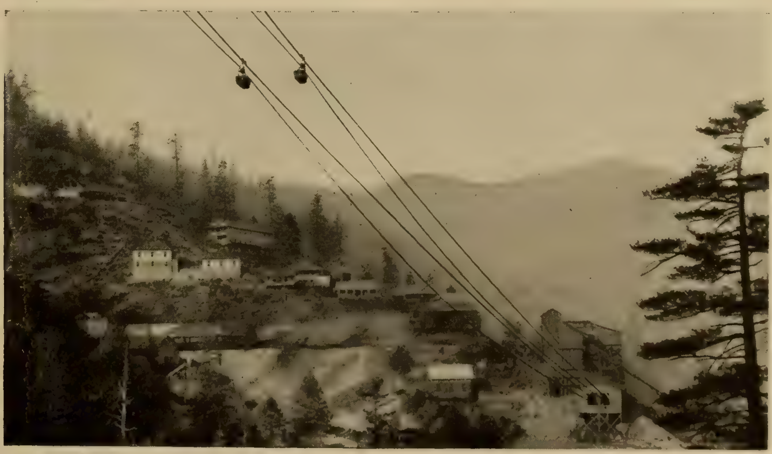
# AERIAL TRAMWAYS OF THE BALAKLALA CONSOLIDATED COPPER COMPANY

By **William Hewitt**

The advantages of the aerial method of conveying material are nowhere more clearly shown than in connection with mining operations, in which the ore or other material is often situated at points almost inaccessible to transport by railway or road vehicles. The aerial tramway enables such material to be taken from points in rough and mountainous country, and delivered over elevations, across valleys, directly to the point where it is to be handled, and this at costs far within commercial requirements. The following article describes such an installation recently made in California, in which copper ore is conveyed for a distance of more than three miles, rising more than 500 feet and descending more than a quarter of a mile, at a rate of more than 50 tons an hour, and at a cost of only a few cents a ton.—THE EDITOR.

THE smelter of the Balaklala Consolidated Copper Company is located at Coram, Shasta County, Cal., on the Sacramento River and the Southern Pacific Railroad. Their mine is about 3½ miles northwest of the smelter in the Squaw Creek range of mountains, 2,243 feet above sea level, near the mine of the Trinity Copper Company. The ores are conveyed from the mine to the smelter by means of a Bleichert Aerial Tramway, the equipment for which was furnished by the Trenton Iron Company, of Trenton, N. J., and installed under contract by James J. Burke & Co., of Salt Lake City, Utah. The line was erected under the supervision of Mr. H. M. Sackett. This tramway was used for a short time also by the Trinity Company, under agreement with the Balaklala Company, for conveying ores from its mine to the smelter at Coram, separate bins being provided at its terminal stations for the ores from the two mines, but the Trinity mine is not now in operation.

The entrance to, as well as exit from, the Balaklala mine is through what is known as the Weil tunnel. The ores are conveyed in trains of eight cars each, hauled by a 6-ton electric locomotive. The cars, which are of steel, holding 3 tons each, dump from both sides. The ore is distributed in the Balaklala Company's bin, which has a capacity of 3,000



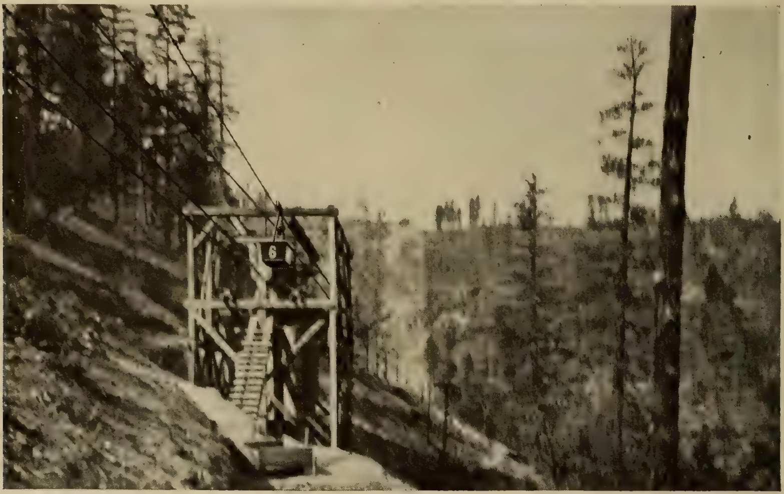
LOADING TERMINAL OF TRAMWAY, SHOWING PORTION OF LONG SPAN ACROSS MULE GULCH.

tons. A platform elevator is provided for raising mine supplies conveyed by the aerial tramway to the level of the Weil tunnel, to be transferred to the mine cars for further transportation, or the supplies may be taken from the elevator at either of the floors of the building for storage.

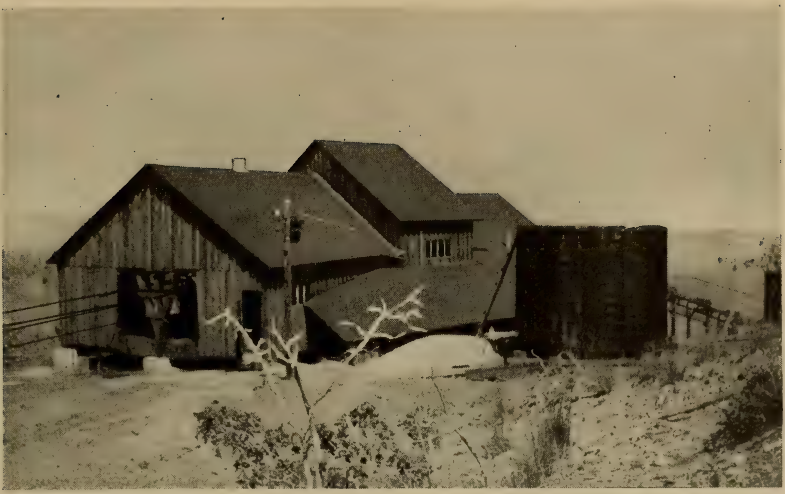
The Trinity mine is about 600 feet below the loading terminal of the aerial tramway, and an inclined plane about 900 feet long, of the skip hoist type with balanced cars holding 3 tons each, affords the means for delivering the ores to their bin, which has a capacity of 940 tons.

The exact distance between the terminal stations of the aerial tramway is 16,220 feet, or a little more than 3 miles. The loading terminal is 1,424 feet above the discharge terminal, which is ample for the line to run by the gravity of the descending ore, developing, when uniformly loaded throughout its length, an excess of power over the amount actually required to run the line, which varies according to the output of ore and amount of back freight carried.

From the loading terminal to the first support the line makes a span of about 950 feet across Mule Gulch, then ascends a mountain slope, reaching the highest elevation, 566 feet above the loading terminal, at a point 2,000 feet distant, where a combined anchorage-tension and curved-rail structure 180 feet long is located. This structure is in no sense a station where the carriers are detached from the traction rope, but merely a support of special construction where the track cables are parted, the cable ends of the lower branch of the line being anchored to the ground and the cable ends of the upper branch weighted to the requisite tension by large wooden boxes filled with rock. The cables of one branch are connected with the cables of the next branch by intervening lines of suspended rails on either side, over which the carriages run with the pendant buckets without interruption or attendance. There is quite a sharp ridge at the summit where this structure is located, and the rails, which are curved to conform to the ground, cover a sufficient length to make an easy transition of the carriers from one grade to the next. The downward pressure of the traction rope here is very heavy, hence rails are substituted for the track cables, which would soon wear out if subjected to such a pressure.



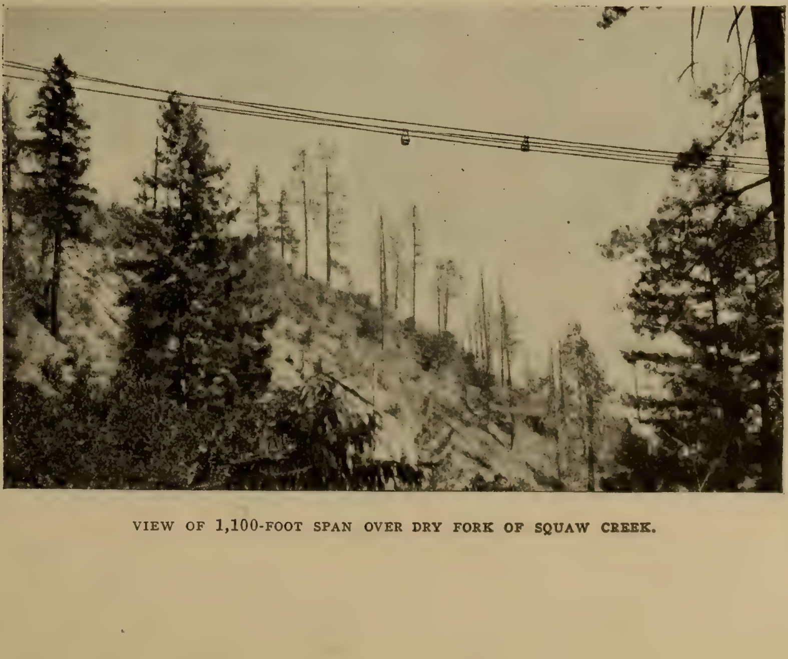
TENSION STATION NO. 1, LOOKING UP THE LINE OF TRAMWAY.



ANGLE AND OPERATING STATION OF THE SUMMIT OF THE MOUNTAIN.

Passing on, we come next to an angle station, where the line makes a horizontal bend of 21¼ degrees and where the operating machinery is installed. This station is located at the opposite brow of the mountain top, 1,900 feet from the summit and 58 feet below it. From this station to the discharge terminal, a distance of 12,320 feet, the fall is 1,891 feet, passing over ground of the most rugged nature, as indicated in the accompanying views.

The angle station practically constitutes the connection of the two sections into which the line is here divided, each with an independent traction rope operated from one of the two horizontal grip wheels mounted on the main shaft. The carriers, as they arrive loaded or empty from either section, are detached from the traction rope of that section and run by gravity along the line of suspended rails on either side to the opposite end of the station, where they are re-gripped to the traction rope of the next section.



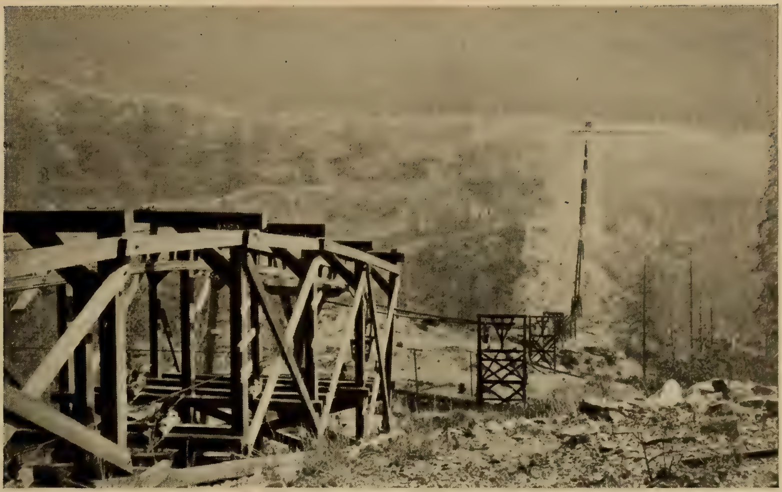
VIEW OF 1,100-FOOT SPAN OVER DRY FORK OF SQUAW CREEK.

VIEW LOOKING UPWARD ON LINE OF AERIAL TRAMWAY FROM A POINT BETWEEN TENSION STATIONS NO. 1 AND NO. 2.

The grip wheels are fitted with brakes for absorbing the excess of power developed, which are operated by hand only when starting or stopping the tramway and are replaced when running by two hydraulic controllers that automatically regulate the speed of the traction ropes. Each controller consists of a closed receptacle containing a specially prepared liquid that is circulated by means of a pump through a valve, the port aperture of which is controlled by a governor that decreases the opening or increases it according as the line may run too fast or two slow, and is so adjusted as to maintain an average speed of 430 feet per minute.

A 40-horse-power electric motor is also provided at the angle station for starting the line, especially after it may have been stripped of the carriers, in order to furnish the power necessary to haul the loaded buckets from the loading terminal up to the mountain to the angle station. The motor is connected to the main shaft by a clutch, which is cut out when a

VIEW DOWN THE TRAMWAY LINE, FACING TENSION STATION NO. 2.

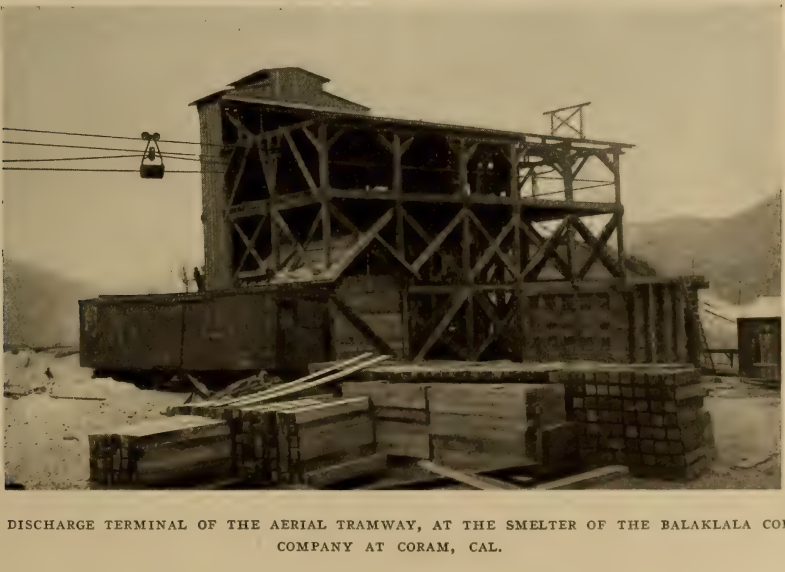


CURVED RAIL STATION ADJOINING TENSION STATION NO. 2, LOOKING DOWN THE AERIAL TRAMWAY LINE AND ACROSS THE VALLEY.

sufficient number have passed over to the descending slopes beyond for the line to run by gravity.

About 1,000 feet from the angle station is support No. 16, the top of which is 234 feet below the rails of the angle station. Between this and support No. 17 occurs the longest span, which is 1,100 feet in the clear with a drop of 165 feet. The bottom of the ravine that this span crosses is more than 300 feet below the cables.

From here on for about a quarter of a mile the line passes over a comparatively level stretch of ground to the brow of the next slope just beyond the first anchorage-tension structure in this section of the line, a view of which is shown. For a distance of 350 feet from this structure and extending over a length of 350 feet, ow-



THE DISCHARGE TERMINAL OF THE AERIAL TRAMWAY, AT THE SMELTER OF THE BALAKLALA COPPER COMPANY AT CORAM, CAL.

ing to the excessive wear of the track cable on the loaded side, this cable was overlaid by a line of suspended rail. The second anchorage-tension structure occurs at a point something over a mile from the angle station, and is about 800 feet below it, annexed to which is a rail structure 135 feet long, where the line makes another steep drop. The third anchorage-tension structure in this section of the line is located about 3,500 feet from the second. From this point to the discharge terminal, about 3,300 feet, there is a gradual fall of 280 feet.

The intermediate supports, 62 in number, are of timber construction, as shown in the accompanying views, and vary from 10 to 80 feet in height.

The track cables are of the locked-coil construction—1½ inch diameter on the loaded side and 1¼ inch diameter on the empty side, each being composed entirely of wires laid in concentric coils into a solid strand, the outer wires of which are so shaped that they interlock one with the other in such a way as to conform to a smooth cylindrical exterior surface. As a track cable this construction has not only been found to be vastly more durable than any kind of cable composed to wire strands, but it also greatly enhances the life of the carriage wheels.

The traction ropes are 1 inch in diameter, composed of 6 strands of 19 wires each, Lang lay, of extra-strong steel.

The buckets, which are of 10 cubic feet capacity, each holding about 1,500 pounds of ore, when running up to the full capacity of 60 tons per hour, which the line is designed to carry, are despatched at intervals of 45 seconds or 322½ feet apart, which corresponds with a speed of 430 feet per minute, making the delivery at the rate of 80 buckets per hour. With such an output about 40 horse-power is required to operate the upper section of the line from the loading terminal to the angle station, and about 90 horse-power developed by the main section from the angle station to the discharge terminal, so that the entire line, as we have already stated, runs by gravity, developing an excess of about 50 horse-power.

The line has been in constant operation since the fall of 1908, with the exception of the months of August and September, 1910, when the smelter was shut down on account of smoke troubles. During the month of January last the line was operated 21 days, running day shift only, with a loss in time of only one hour and fifty minutes, notwithstanding the fact that unusually bad weather was experienced all the time, such as would have blocked a surface road at least three times. During this time 9,857 tons of ore were transported at a cost of 9.8 cents per ton, which is equivalent to a cost of 3.16 cents per ton per mile. During the month of February, running with equally bad weather, the cost of transporting the ore was less than 3 cents per ton per mile, with an average output of about 51 tons per hour. If the output of ore had been up to the full capacity of the tramway, 60 tons per hour, the cost of transportation would have been proportionately less, probably not more than 2½ cents per ton per mile.

In erecting the supports it was intended, at the outset, to put in wood and earth foundations, but after installing the supports between the loading terminals and the angle station with the such foundations the winter rains stopped the work, and the balance of the line was then installed with concrete foundations, which added materially to the cost of the installation.

# THE HEATING VALUE OF FUEL OIL

The great interest which is being attracted toward the use of oil fuel renders important the work which is being done by the United States Bureau of Mines in providing specifications to govern the purchase of such material upon a scientific basis. We, therefore, give the substance of a communication just issued by the Bureau, believing that it will prove most acceptable, both to dealers and to purchasers, and also to engineers who are investigating the relative usefulness of solid and liquid fuel in any particular locality.—The Editor.

IN consequence of the success that has attended the use of heating-value specifications in buying and selling coal there has arisen a demand for similar specifications, based on careful tests, to govern the purchase of fuel oils and the refined products of petroleum. The Bureau of Mines has, therefore, issued Technical Paper No. 3, by Irving C. Allen, on "Specifications for the Purchase of Fuel Oil for the Government," with directions for sampling oil and natural gas.

"These specifications, to be satisfactory," says the author, "should establish not only the heating value of the oil, and thus show, like the specifications for coal, the number of heat units the purchaser obtains for a given price per unit quantity of fuel, but also the physical character of the oil, its flash point and burning point, and the quantity of extraneous matter it contains.

"It is evident that an essential feature of any such plan of purchasing oil in bulk is an equitable method of sampling deliveries—that is, a method that insures the taking of representative samples.

"The Bureau of Mines has received many inquiries from Government bureaus and from private concerns regarding fuel-oil specifications and the sampling of purchases. In reply to these inquiries the bureau issues this paper, which, although intended primarily for the guidance of Government officials, may be of service, the bureau trusts, to all persons who buy or sell fuel oil."

General specifications for the purchase of fuel oil are given as follows:

In determining the award of a contract consideration will be given to the quality of the fuel offered by the bidders, as well as the price, and should it appear to be to the best interest of the Government to award a contract at a higher price than that named in the lowest bid or bids received the contract will be so awarded.

Fuel oil should be either a natural homogeneous oil or a homogeneous residue from a natural oil; if the latter, all constituents having a low flash point should have been removed by distillation; it should not be composed of light oil and a heavy residue mixed in such proportions as to give the density desired.

It should not have been distilled at a temperature high enough to burn it, nor at a temperature so high that flecks of carbonaceous matter began to separate.

It should not flash below 60 deg. C. (140 deg. F.) in a closed Abel-Pensky or Pensky-Martens tester.

Its specific gravity should range from 0.85 to 0.96 at 15 deg. C. (59 deg. F.); the oil should be rejected if its specific gravity is above 0.97 at that temperature.

It should be mobile, free from solid or semi-solid bodies and should flow readily at ordinary atmospheric temperatures and under a head of 1 foot of oil through a 4-inch pipe 10 feet in length.

It should not congeal nor become too sluggish to flow at 0 deg. C. (32 deg. F.).

It should have a calorific value of not less than 10,000 calories per gram

(18,000 British thermal units per pound); 10,250 calories to be the standard. A bonus is to be paid or a penalty deducted according to the method stated under Section 21, as a fuel oil delivered is above or below this standard.

It should be rejected if it contains more than 2 per cent. water.

It should be rejected if it contains more than 1 per cent. sulphur.

It should not contain more than a trace of sand, clay or dirt.

Each bidder must submit an accurate statement regarding the fuel oil he proposes to furnish. This statement should show: The commercial name of the oil; the name or designation of the field from which the oil is obtained; whether the oil is a crude oil, a refinery residue, or a distillate; the name and location of the refinery, if the oil has been refined to any extent.

The fuel oil is to be delivered f. o. b. cars or vessel, according to the manner of shipment, at such places, at such times, and in such quantities as may be required, during the fiscal year ending ———.

Should the contractor for any reason fail to comply with a written order to make delivery the Government is to be at liberty to buy oil in the open market and charge against the contractor any excess of price above the contract price of the fuel oil so purchased.

Copies of this Technical Paper may be obtained by addressing the Director of the Bureau of Mines, Washington, D. C.

Reginald Pelham Bolton was born in 1856, and received his early training in England in the workshop and drafting room. In 1879 he came to the United States and entered the service of the Edgemore Iron Works, and afterwards with Dr. Erasmus D. Leavitt, after which he returned to England and became works manager for the firm of Appleby Bros., Ltd., in the manufacture of hoisting machinery and the construction of the Greenwich steam ferry. Mr. Bolton was next engaged as consulting engineer in the construction of engines and boilers for vessels in Italy, also dredging and pumping machinery in Sicily, Holland and Spain. He designed a number of small vessels for special service for Mexico, South America and Egypt, including trials of both government and merchant vessels. In 1894 Mr. Bolton removed to New York and began practice as consulting engineer in connection with the engineering equipment of tall buildings, making a specialty of the inter-relation of the entire steam, electrical, elevator, sanitary and other elements, and developing the harmonious design of piping for these services. Among the buildings which have been equipped from the designs of Mr. Bolton may be mentioned Lords' Court, Central National Bank, Broadway Chambers, Hudson and other office buildings; also the Lorraine, Ansonia and other hotels, as well as the equipment of the remodeled Grand Central Station in New York. He has been active in the introduction of the plunger elevator in New York City, overcoming difficulties in the rock boring, and he is an authority on elevator service, motive power, electric wiring, and the mechanical equipment of buildings, making radical departures from ordinary methods, introducing the vertical system of electric wiring, vacuum system of heating, multiple pressure drum system for water supplies and duplex pressure system of elevator operation.

He is a member of the Institution of Civil Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, Society of Heating and Ventilating Engineers (formerly vice-president and now president), and recipient of the Telford Gold Medal and Telford Premium of the Institution of Civil Engineers.

Among his contributions to technical literature may be mentioned a work on "Elevator Service," upon "Motive Powers and Their Practical Selection," as well as contributions to the transactions of the professional societies, and papers and addresses relating to educational work and to the local history of Manhattan.

REGINALD PELHAM BOLTON.

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INDEXED

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# GREAT WATER POWER SITES

By Henry Hale

In looking forward towards the time when the increasing scarcity of fuel will lend additional importance to the development of power from falling water, it is desirable to see what has already been done, compared with the opportunities yet remaining available. Niagara has been largely developed; the Falls of the Rhine have power houses on the banks, and many natural and artificial sites have been partially utilised. There are, however, many points yet untouched. The falls of the Zambesi may come next, and the great cataract of Iguazu, in South America, has already been indicated in these pages as awaiting only capital and engineering skill. Mr. Hale discusses what has been done in many parts of the world, and his paper should serve as a stimulus for further development of this great source of power in Nature.—THE EDITOR.

WHILE the hydro-electric source of power is still in the beginning of its development such is the number of natural sites available that no calculation can be accurately made as to the extent to which it will be installed throughout the United States for industries, illumination and other purposes. We have fairly accurate knowledge of the principal water-power sites through the investigation of the Geological Survey and hydrographic experts. It has been estimated by Prof. W. C. Unwin that the total available water power in the United States is more than 30,000,000 horse-power, and that this can be increased to 150,000,000 horse-power by storage reservoirs. It is estimated that the difference in cost of steam power and water power is $10 per horse-power per year, at the minimum. Thus the manufacturing regions of the Southern States alone, which are depending on steam instead of water power, would save $30,000,000 per year alone.

The development of the water power at Niagara indicates the possibilities of the manufacture of electricity. The power that Niagara might generate is estimated by Professor Unwin at 7,000,000 horse-power. The same authority estimates that there are fully 2,000,000 horse-power available on the upper Mississippi, while the southern Appalachian region can furnish a minimum of 3,000,000 horse-power.

While the volume of water in a river adds to the force the head of water caused by its rapid descent is far more effective in proportion to its volume. A mountain stream of moderate size may become the source of far more power than a large river with a slowly-flowing current. An illustration of this is given in Switzerland, where many electric power stations for railways and illumination are served by heads of water from small streams falling over mountain precipices. The same is true in the United States. When the famous Gunnison tunnel in Colorado was

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POWER IN A CANAL DISCHARGE INTENDED ORIGINALLY ONLY FOR IRRIGATION

opened for irrigation the only thought of its importance was the fertilization of 250,000 acres of desert. But the experts who constructed it knew that this conduit of 7 miles in length, carrying the waters to the Uncompahgre Valley, developed such a head of water in its descent from the surface of the river to the valley that the five artificial cataracts over which it falls are each capable of actuating turbines of 5,000 horse-power, thus developing 25,000 horse-power from a source only 12 feet deep and 8 feet wide, as this canal is measured in the tunnel.

The Ohio River system is one of those which have been extensively surveyed by the United States Government in connection with the consideration of the feasibility and cost of regulating the flow, reducing the flood run-off, and thus aiding navigation and incidentally water-power developments; and from these investigations it appears that the water-power capacities of the different tributaries in the present unconserved, and the feasible controlled conditions are:

River System: Cumberland, Green, Kanawha, Kentucky, Monongahela, Ohio, at Louisville, Ky.:

POWER CAPACITY.

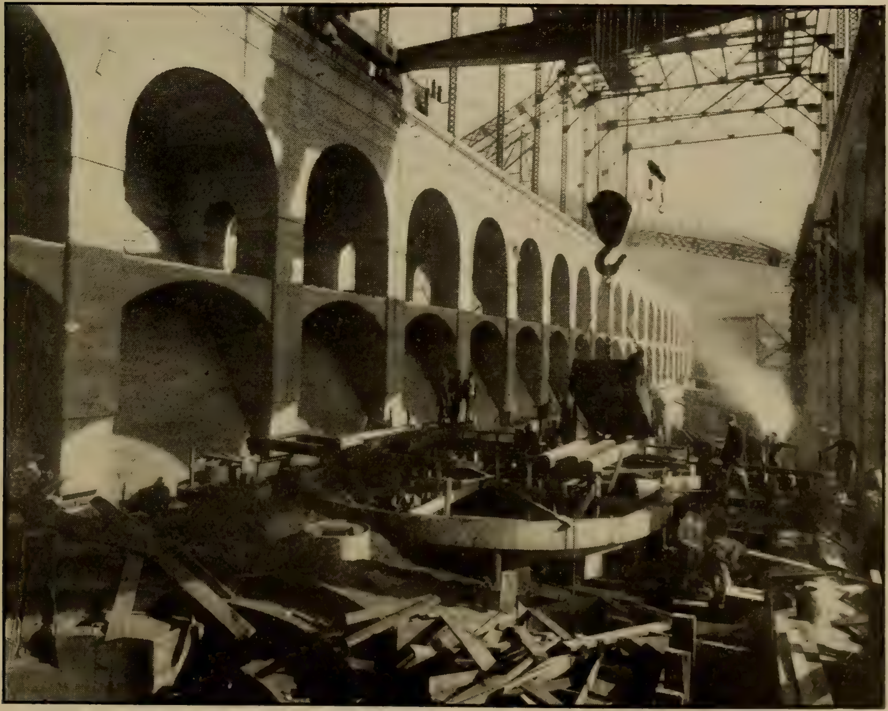
| With Present Unconserved Flow. Horse-Power. | With Regulated Flow. Horse-Power. |
|---|---|
| 20,000 | 200,000 |
| 6,000 | 30,000 |
| 335,000 | 800,000 |
| 10,000 | 80,000 |
| 11,000 | 90,000 |
| 8,000 | 110,000 |
| 1,000,000 | 3,500,000 |
| 1,390,000 | 4,810,000 |

That we are realizing the economy and efficiency of the hydro-electric service is shown by the remarkable increase in its development. The total electrical power thus generated in the United States in 1900 was but 493,000 horse-power; in 1905 it was 1,592,000. The increase during the last five years has been far greater in proportion, owing to the completion of plants ranging as high as 100,000 horse-power. Among these is that of McCall's Ferry, on the Susquehanna River.

The dam upon which the plant depends for its supply of water is 3,000 feet long in all. It is 68 feet wide at the base and the outer wall in the shape of a parabola, so as to throw the water away from the bottom of the wall and keep it from undermining it. The height of the dam varies, according to the depth of the river bed, from 50 to 100 feet. Its average height is 53 feet. It contains 380,000 cubic yards of concrete, one of the largest masses of the material ever constructed, and causes a storage area to be formed 8 miles long and half a mile wide, which will contain about 32,000,000,000 gallons of water. The power house, which is at the east end of the dam, is about 450 feet long by 165 feet wide.

The equipment of the power plant includes ten pairs of turbines. The runners are 8 feet 10 inches in diameter. To reduce friction each pair is carried on an oil thrust bearing, into which a film of oil will be fed, under a pressure of 250 pounds to the square inch, by an independent 50-horse-power turbine. Each pair of turbines is coupled direct to an electric generator with a rotor 27 feet in diameter and weighing 145 tons. The turbines, operating under 53 feet head at 94 revolutions per minute, will each generate 13,500 horse-power. If they were operated under the head available at Niagara Falls they would be capable of generating 40,000 horse-power. The maximum capacity of the plant under favorable conditions is 135,000 horse-power at the power house.

In the construction of the station an erecting bridge of concrete was required, as no false work of wood would resist the river in flood. The bridge which was removed after the completion of the work was 2,000 feet long, with arches of 40-feet span and with a roadway 50 feet wide, carrying four railroad tracks, built in the record time of sixty-seven days.

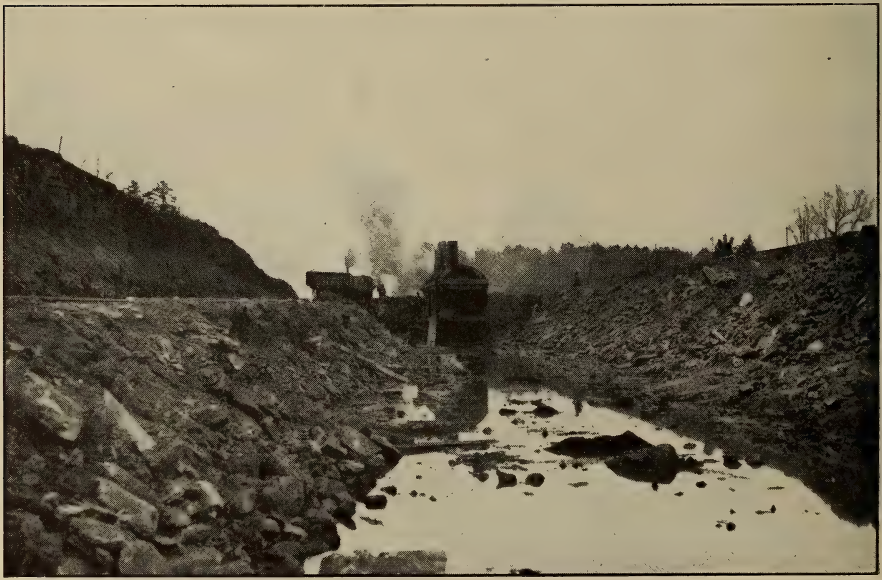


INTERIOR OF THE POWER HOUSE AT MC CALL'S FERRY, PENNSYLVANIA, UNDER CONSTRUCTION

EXCAVATING FOR THE FOUNDATION OF A POWER SITE DAM

It was so solid that it passed unharmed through floods, during which it was completely submerged. This bridge cost $200,000 to build, but as the interest charges on capital amount to $15,000 a month it is estimated that the bridge paid for itself in interest saved through expediting the work.

Another important feature which facilitated rapid construction was the concrete-mixing plant, in which material was handled almost entirely by gravity. The only manual labor required was for manipulating the levers that empty cars into bins and bins into cars. As it was mixed it was dumped into buckets, each holding 1 cubic yard, which were transferred to the works on cars holding two buck-



HYDRAULIC CANAL CONSTRUCTION, PALMERSVILLE ets each. In trains of eight cars the buckets were hauled out to the work by small locomotives at a speed of 12 miles an hour upon the construction bridge just below and parallel to the dam. Here two traveling cranes, each with four booms 109 feet long, served the loaded buckets of concrete and hoisted them out to the particular spot where they were needed. So swift and methodical were the movements of the trains and cranes that the concrete was in place in the dam within ten minutes after it was mixed.

CONSTRUCTING THE YADKIN DAM, SHOWING SECTION AND DOWN-STREAM FACE

The abundance of water power for electrical generation afforded by Southern rivers (as already noted) is the reason for several very extensive installations for serving cotton mills and other industries. In no part of the South is this more demonstrated than in the Piedmont cotton belt, which covers the States of North and South Carolina and a portion of eastern Georgia. Running diagonally across this cotton belt, in a general direction northwest to southeast, is the Santee River drainage system, with the tributaries of this river spread over a territory of approximately 15,000 square miles.

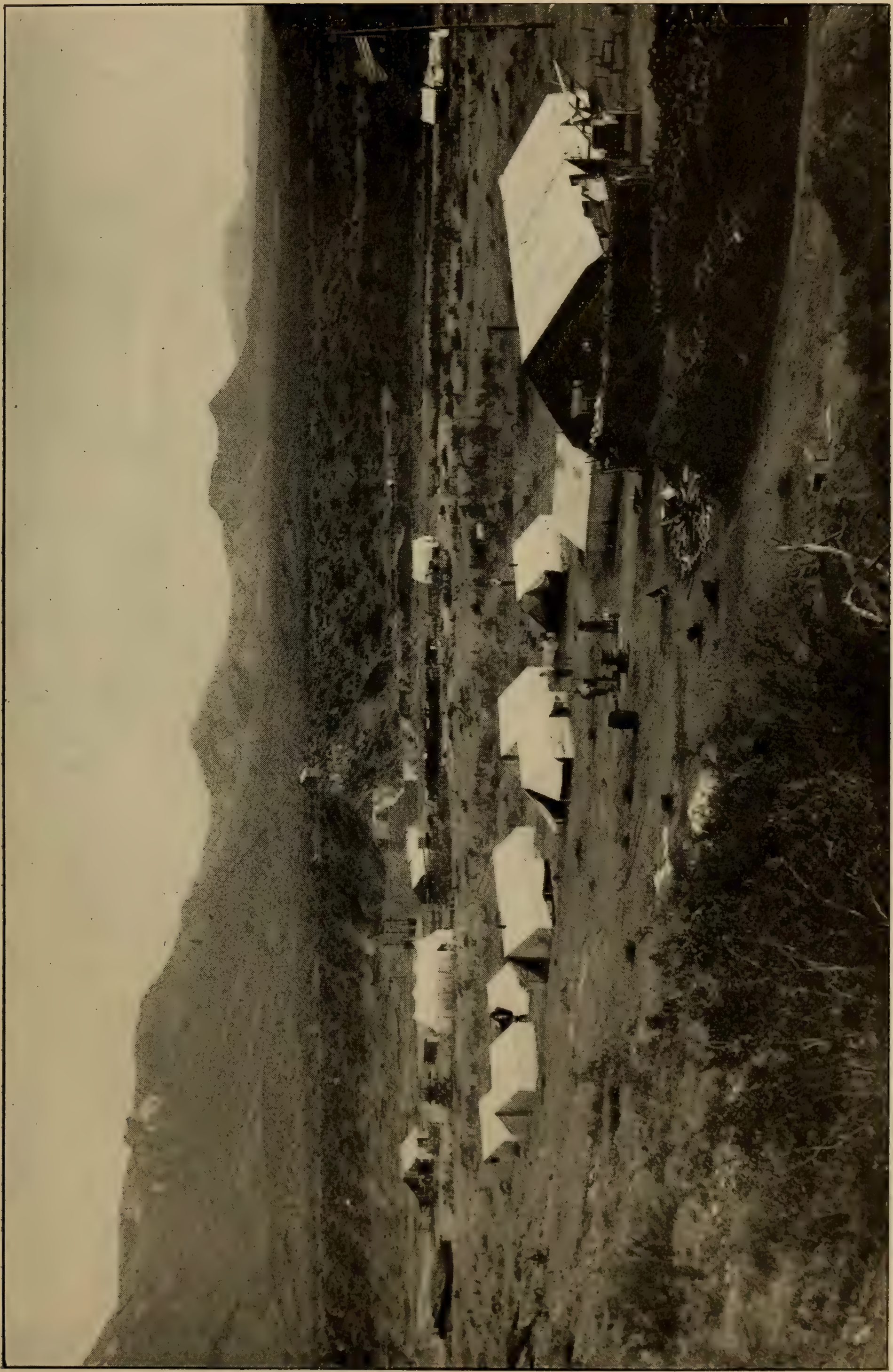
It is here that the Southern Power Company is operating. The bulk of the hydro-electrical development done by the company has been along the course of the Catawba River, which is one of the tributaries of the Santee. The first transaction of the Southern Power Company was the acquisition of the partially-completed hydro-electric plant of the Catawba Power Company, situated on the Catawba River, about 25 miles southwest from the city of Charlotte. The drainage area back of this plant is about 3,000 square miles, and the hydraulic development consists of a heavy masonry ogee section, and overflow type dam, 1,266 feet in length, with a spillway section of 585 feet. A portion of one of the shore ends of the dam is of the earth-filled masonry type. The dam gives a normal operating head of 25 feet, backing the water up stream a distance of more than 12 miles, with an average width of over 550 feet. Due to the great amount of silt, which is characteristic of the rivers in this section, only the higher levels of the stored water are available for power purposes, the pondage at the Catawba plant giving an average of 30,000,000 cubic feet of water for each foot of the higher levels.

The maximum height of the dam from foundation to crest is about 25 feet, while its thickness at the base varies from 40 to 43 feet, the foundations all resting on granite bedrock. The heart of the dam is made altogether of cyclopean masonry, the interstices being filled with concrete and the surface smooth finished with concrete. The power house, which is sealed in the rock of the river bank on one side, comprises part of the dam.

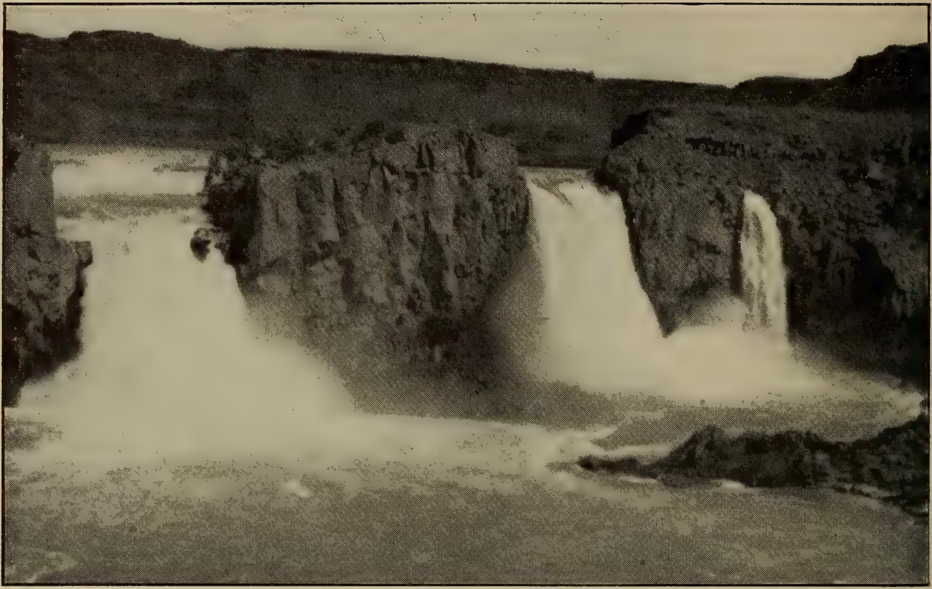
The electrical equipment consists of four 750-kilowatt generators and four 900-kilowatt generators. In each of these, generators are located above their respective wheel-pits and are connected to the turbines by a rope drive system. This power house was originally intended to serve a territory within a radius of 18 miles, but its transformer equipment is now so arranged that it can operate in multiple with the power houses of later construction, which are located at the Great Falls of the Catawba River, about 30 miles south of the Catawba station. The transformer equipment at Catawba consists of three water-cooled transformers of 2,000-kilowatts capacity. The entire electrical equipment of this station, except the transmission lines, is of General Electric manufacture.

The Great Falls of the Catawba River are located about 55 miles south of Charlotte and consist of a series of falls and shoals extending for a distance of about 8 miles and giving a total drop of 176 feet. The topography of the country at this point rendered it inadvisable to attempt the development of the entire head in a single plant, and after careful preliminary work the Southern Power Company decided to construct three power stations. Two of these have already been completed and are now in operation. The Great Falls Station has one impounding and two diverting dams, and operates under a head of 69 feet, developing 42,000 horse-power. The machine equipment of the Great Falls power house comprises ten turbine-driven generators. Eight of these units consist of 5,200-horse-power reaction turbines, driving eight 3,000-kilowatt generators. The two remaining machines are exciter units and are made up of 700-horse-power turbines. At a distance of about 2 miles south of the Great Falls station the second power plant, known as the Rocky Creek station, has been constructed. This consists of a massive spillway dam, extending across the river for a distance of 1,000 feet, its height from foundation to crest averaging about 60 feet and its width at the base being somewhat in excess of 70 feet. Along the west bank of the river, a canal 600 feet long and 80 feet wide at the bottom carries the water to the power house. Eight 3,000-kilowatt turbo-generator units have been installed, and the transformer equipment consists of twelve kilowatts, 60 cycle units. The current is generated at 2,200 volts and stepped up for transmission to 44,000 volts, the transmission line being tied in with that of the Great Falls and Catawba stations.

The Southern Power Company depends almost entirely on its hydro-electric plant for its supply of current. The water power resources of the Southern Power Company as a conservative estimate total 320,000 horse-power. Of this total plans have been prepared for the development of 270,000 horse-power, including those stations already completed and under construction. The generator capacity



ENGINEERS' CAMP AT THE INTAKE OF THE POWER CANAL. SALT RIVER PROJECT, ARIZONA



THE GREAT TWIN FALLS OF THE SNAKE RIVER, IDAHO

of the Catawba, Great Falls and Rocky Creek stations amounts to 64,600 kilowatts, and there is now nearing completion a power house which will develop 18,000 kilowatts. This is located on the Broad River of the Carolinas and utilizes a head of 72 feet.

When the company was first organized the total power supplied was 1,460 horse-power, which was delivered to three cotton mills in one town. To-day the connected load is approximately 70,000 horse-power, and the service reaches 110 cotton mills in forty-two towns and cities in North and South Carolina. Many of the mills which changed over from mechanical to electric drive have enlarged their equipment, and forty-one new mills have been designed especially for electric drive. At the present time the General Electric Company has installed in textile mills in this vicinity about 8,000 motors, aggregating more than 185,000 horse-power; of these 727 motors, with a total of about 22,000 horse-power, are installed in mills on the Southern Power Company's system.

On the Yadkin River, in the State of North Carolina, a series of plants for generating electric current for power and lighting purposes is being completed which is among the most extensive thus far planned in the Southern States, and one of the most extensive yet designed in America, by reason of the total output of horse-power. The sites of the plants are well located, not only from an engineering but from an economic standpoint. They are on what is called the Narrows of the river. Within a distance of 4½ miles the stream has a total fall of 129 feet, the maximum descent being 90 feet in a distance of a mile, while at the lower end of the Narrows there is a fall of 200 feet in a length of 10 miles. According to the calculations of the supervising engineers the volume and head of water are ample to produce at least 110,000 electrical horse-power to be secured from three stations, the largest of which will have a capacity of 48,000 horse-power.

The works include the dam for serving the power canal, protection dams, the canal itself and power house. As the other generating stations will conform to the one being completed in the general plan, a detailed description of it will give an idea of the magnitude of the entire project. The main dam itself is 1,000 feet in length at the crest, with a height above the average level of the river bottom of 38 feet. Its width at the base is 58 feet, at the crest 12 feet, the top of the dam being ogee down stream and vertical up stream with a straight alignment. Owing to the great variation of the river's depth at different seasons of the year the plans included unusual precautions to prevent the structure from being damaged or destroyed. This is an excellent example of modern engineering, the material being dimension granite laid to half joints, the blocks being set in cement mortar. The blocks average 10 tons in weight. As the bed of the river is of hard rock the solid foundation has been obtained for the dam with little difficulty. The preliminary work, however, includes an unusually large cofferdam, which has also been utilized to support tracks for tramways, lifting derricks and other mechanism employed in connection with the project. When in flood the river frequently rises to a height ranging from 20 to 25 feet above its normal depth. As a reinforcement to the main dam a core dam 300 feet in length has been constructed along the east shore of the river. This is composed entirely of concrete. Between the dam and the core is an abutment which rises to a height of 20 feet above the crest of the main dam, thus acting as a barrier to prevent flood water from working around the end and to check the direct force of the current. The spillway is 1,500 feet in length, of the same height as the masonry work, and has a width of 40 feet at the base. It is also composed of granite blocks, set according to the same specifications. To serve the largest power station a canal 4½ miles in length has been provided, with an average width at

FALLS OF THE SNAKE RIVER, IDAHO. UTILIZED FOR THE GENERATION OF ELECTRIC POWER AND IRRIGATION

HIGH-PRESSURE CONDUIT IN SOUTHERN CALIFORNIA. WOOD STAVE PIPE 40 INCHES IN DIAMETER

the surface of 112 feet, narrowing to 40 feet at the bottom and containing a minimum depth of water of 18 feet. With this conduit a flow of 3,300 cubic feet per second will be supplied the generating mechanism, with a total head of 129 feet.

The power house is 80 feet wide, 300 feet long and 100 feet in height. The material of which it is built is of concrete and the interior is so arranged as to leave ample space for the machinery without the obstruction of posts or other barriers. The total capacity of this power house completely equipped is 48,000 horse-power. The installation includes a series of six generating units, representing 9,000 mechanical horse-power each. Each unit consists of one turbine of the indicated horse-power, shaft generators being mounted upon the upper ends of the turbine. The revolving elements of each unit will weigh 70 tons. The type of the construction is the vertical shaft system, electrical generators being mounted on the shafts of a capacity to deliver current at a pressure of 11,000 volts. Operating at a normal load the series of units will have a capacity to supply about 41,000 electrical horse-power, but, as already stated, their maximum capacity is 48,000 horse-power continuously. The turbines are direct connected with the generators, which will furnish a 3-phase 60-cycle current, each generator carrying its own exciter. An interesting feature of the installation, however, is that the controlling switchboard is so arranged that any exciter may be used to actuate any generator. As most of the power is intended to be utilized at a considerable distance from the stations, provision has been made for a series of transformers which will increase the voltage from 11,000 to 30,000 volts, where it is to be carried a maximum distance of 40 miles, but the transmission lines will extend as far as 75 miles from the river, and above the 40-mile limit the voltage will be raised to 60,000.

It is calculated that the textile plants alone utilizing the power will consume the maximum quantity which will be generated at the three sites, for over fifty such plants are within a radius of 75 miles from the water course. The project, therefore, presents an illustration by which the cost of operating steam-driven mills, such as the ones located in this sec-

SETTING THE 16-TON BLOCKS IN THE FOUNDATION OF THE ROOSEVELT DAM

tion of the South, can be contrasted with similar plants operated by electric power from an isolated station. Before beginning work the company, of course, calculated the cost of current and its transmission to the factory as compared with the cost of coal for steam fuel and other expenses incidental to steam power. The average cost of developing horse-power with steam coal in this section of the country ranges from $35 to $50 per year, based on the price of fuel alone. The calculations of the engineers of the

UNLOADING OIL AT ROOSEVELT, ARIZONA

This oil is hauled from Mesa to the Cement Mill, a distance of sixty miles, over the Government road.

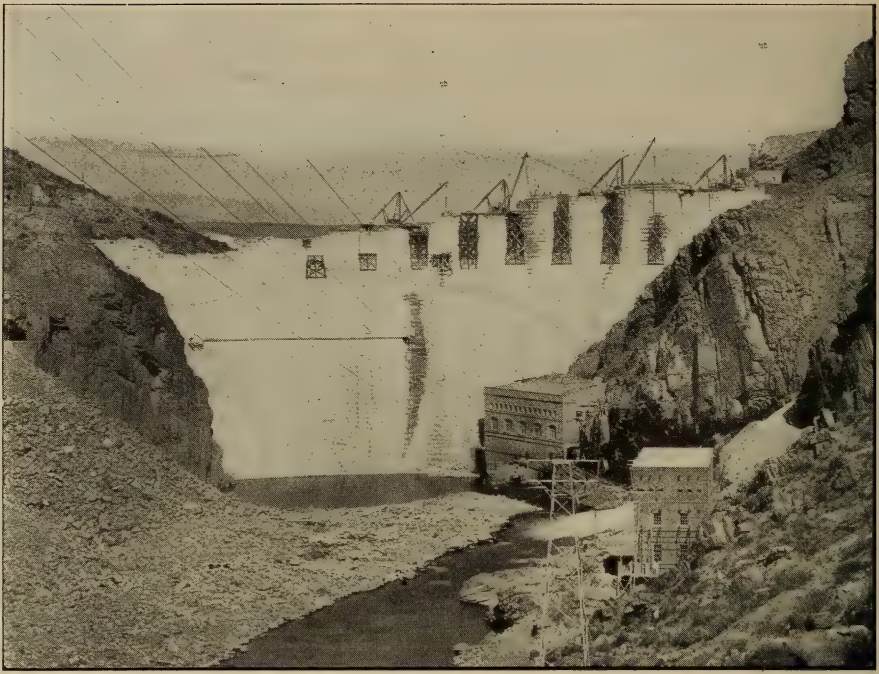
power company are that electric current can be generated and transmitted the greatest distance, 75 miles, at a cost of only $25 per horse-power annually. These figures are based on a rate of $3.60 per ton for coal—the average price paid for steam fuel in the vicinity.

As an indication of the employment of a small water course in the eastern United States for generating power current, the Schaghticoke is worthy of note. The Hoosac River has been barred by a concrete dam that is built in thirteen sections, with expansion joints between sections; has a net length of 680 feet on the spillway, with a maximum height from foundation to crest of 29 feet, and contains more than 9,000 cubic yards of concrete. The height of the spillway proper varies from 21 to 24 feet, the difference in the various sections being due to the irregular contour of the river bed; this height can be somewhat increased by the use of flash boards. The thickness of the dam at the base varies from 24½ to 28¾ feet. The storage capacity of the Schaghticoke dam is 25,600,000 cubic feet. The canal forebay, at which point are located the canal intakes, eight in number. The canal runs from the west bank of the river directly across the neck of land formed by the first bend in the river below Schaghticoke. It curves slightly toward the north at the start and then runs northwest in a practically straight line, its total length from intake to lower end being somewhat less than half a mile. For a part of this distance the canal is cut through solid rock, while the bottom is bedrock from end to end. The width of the canal at the surface of the water varies with the contour of the land, but the bottom is uniformly 20 feet wide. At the lower end of the canal is situated the intake for the inverted syphon which carries the water across the river to the surge tank. This intake is 35 feet 6 inches in width, and is divided laterally into four sections, each of which is provided with heavy iron screens, the actual intake to the syphon being well below normal low water level. The masonry work is all of concrete.

The power house is of brick and steel construction, with foundations, flooring and wheel-pits of concrete. The penstocks pass beneath the power house floor and lead directly to the wheel-pits, where the four vertical Pelton-Francis generator turbines are located. These turbines are designed for a normal output of 5,000 horsepower at a speed of 300 revolutions per minute under a head of 146 feet. They consist of three main parts—namely, the revolving element, the stationary vanes or blades mounted in the turbine casing, and the controlling apparatus. The four generators are of General Electric make. They are 3-phase, 40-cycle, 16-pole vertical machines, each generator having an output of 3,000 kilowatts and 4,400 volts.

ELECTRIC DERRICKS SETTING BLOCKS ON THE SALT RIVER DAM. THE CURRENT IS SUPPLIED FROM THE POWER CANAL

At Johnsonville is another station auxiliary to that at Schaghticoke. Here has been built a second dam. The dam is made of solid concrete and is built up in eleven sections with expansion joints every 50 feet. It is of the ogee type, with a total spillway length of 530 feet, a maximum height of 40 feet and its greatest thickness at the base is about 30 feet. Both of the height and thickness of the dam diminish near the south shore, where the river bed is higher. The power house connected with this dam has an installation in each flume of a 57-inch double runner reaction turbine of the horizontal Francis type. The wheels discharge into a common draft chest located between the runners, and the amount of water which is admitted to the wheels is controlled by wicket gates mounted in a ring around the runners and operated by a common rotating shaft which is geared to the governor in the generating room. When operating under a 35-foot head



VIEW OF ROOSEVELT DAM UNDER CONSTRUCTION. THE POWER HOUSE FURNISHING CURRENT IS SEEN IN FOREGROUND

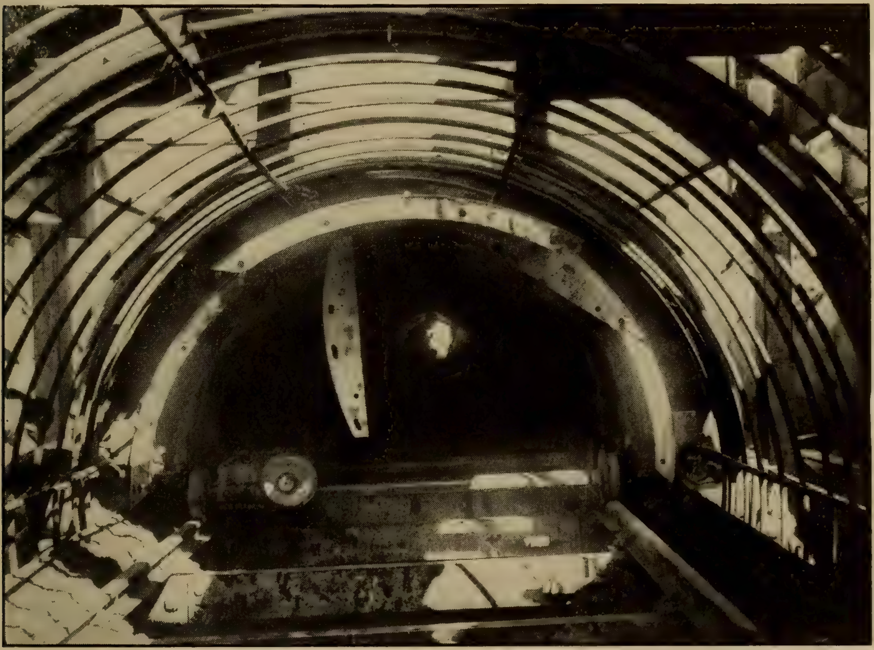
the turbines develop 3,000 horse-power, and when the water is drawn down to a 24-foot head the output is reduced to 1,750 horse-power. The generator equipment consists of two 1,800-kilowatt, 4,400-volt generators, direct coupled to the turbine shafts. The machines are of the horizontal shaft, two-bearing revolving field type, designed for waterwheel drive, and are provided with an exciter.

These two stations, deriving their power from one small river, serve industries in the two cities mentioned, as well as furnishing illumination. The entire development was designed and constructed by Messrs. Viele, Blackwell & Buck, of New York; the hydraulic machinery was supplied by S. Morgan Smith Company, of York, Pa., and all the electrical apparatus by the General Electric Company.

The International group of power plants that utilize the head of water at Niagara have a combined horse-power greater than any in the world. With the additions planned the total will reach fully 500,000, including the small plants along the Welland Canal. Of this, 228,000 horse-power is developed on the Canadian side. Thomas Evershed, who originated the idea of securing current on the American side, had his plans practically adopted in the two largest hydro-electric installations which have been completed on this shore of Niagara. The first one contains a wheel pit 425 feet in length and 18½ feet wide, excavated through the rock to a depth of 178½ feet. Connected with it is a power canal 1,700 feet in length, 250 feet in width, and 12 feet deep, giving a head of water ample to operate turbine water-wheels, each developing 5,000 horse-power. The latter installation is in a wheel pit of the same depth, but 464 feet long and 18½ feet in width. It contains ten generating units connected with turbines, developing in all 55,000 horse-power, making the total of the two plants over 100,000 horse-power. The new turbines and generators weigh

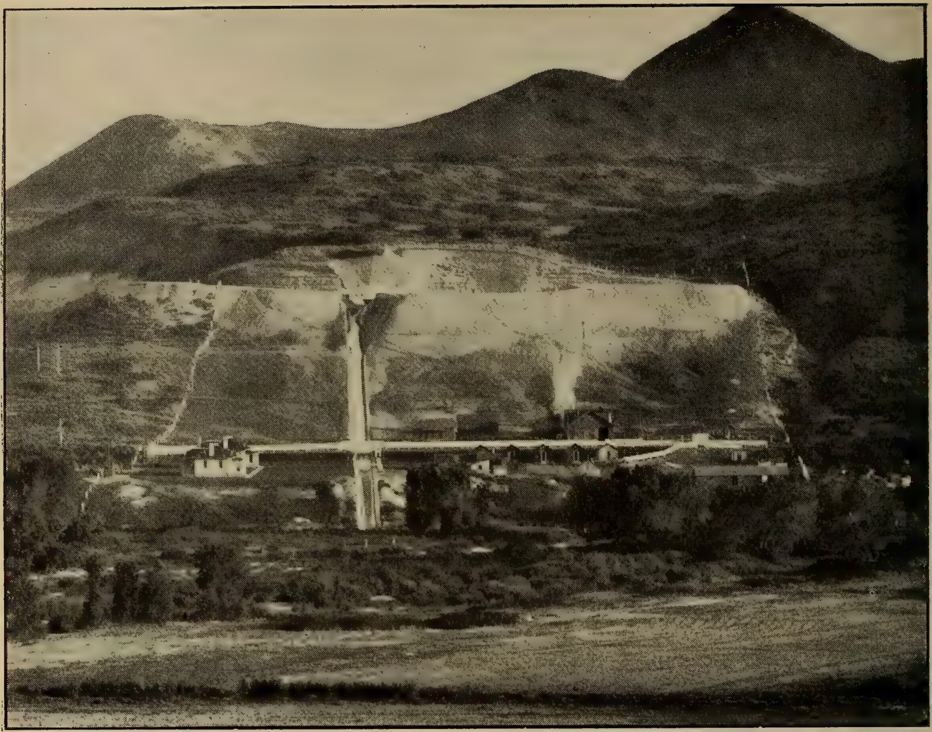
75 tons each. The turbines were built by Faesch & Piccard, of Geneva, and I. P. Morris & Co., of Philadelphia. The electrical equipment is of the Westinghouse type.

One of the most interesting hydroelectric stations recently completed is that of the Great Northern Power Company. It is situated on the St. Louis River, near Duluth, Minn. In a distance of 8 miles the river has a total fall of 464 feet over a series of rapids, and near the head of these the Great Northern Power Company has constructed a concrete dam 1,120 feet long. An additional spillway 1,000 feet in length was also formed by dressing off the top of a natural ridge of slate rock. This dam forms a service reservoir of about three-fourths of a square mile in area, at the southeast corner of which is located another concrete dam, with racks and head gates to admit water to a canal 2 miles long, 70 feet wide and 15 feet deep, which ends in a forebay covering 40 acres. The service reservoir, 464 feet above Lake Superior, has a gross capacity on its 12 feet of available draft of 130,000,000 cubic feet of water, amply sufficient to accomplish the purposes of conservation and regulation. This reservoir is about 1½ miles by ½ mile in surface area. The main dam was built across the channel, with a dozen low dams of earth, rock with concrete core, and concrete connecting the slate walls. Most of the last named are retaining dams of the gravity type.



INTERIOR OF POWER CANAL CONNECTED WITH THE ROOSEVELT DAM IN ARIZONA. STEEL AND CONCRETE CONSTRUCTION, CONVEYING 4,400 HORSE-POWER

The canal into which water from the service reservoir passes is 8,500 feet long and excavated for its entire length in the slope of a hillside. For a mile of its length it is through clay and occasional rock ridges; the remainder of its length is in slate rock section, with some earth interposed. The limiting condition of construction of the earth section was the required capacity of the canal, or

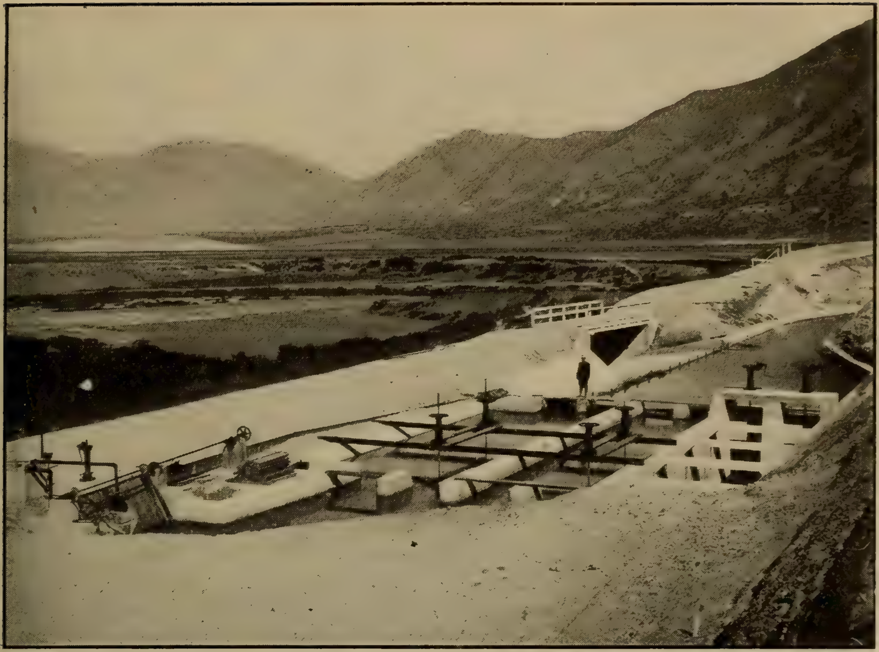


POWER PLANT IN THE STRAWBERRY VALLEY, UTAH

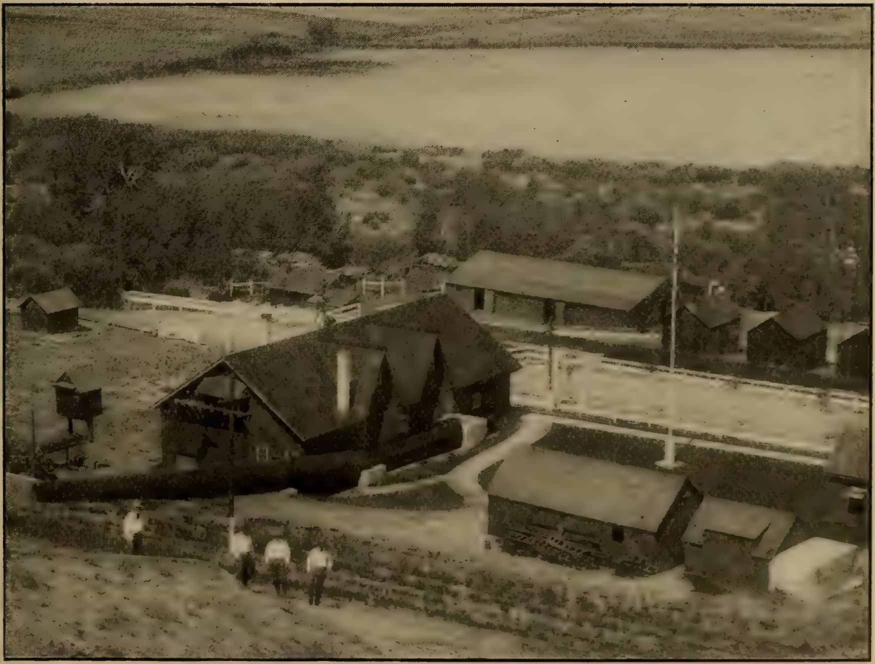
The waste water is utilized for irrigation, while the electric current generated is employed for power and illumination.

sufficient water to supply 80,000 horse-power at the power house, and erosion of its banks based on a flow of water of 3 feet per second. In order to harmonize conditions it was planned for a cross-section 36 feet wide at the bottom, a depth of 15 feet and slope to 2 to 1. It was originally intended to line the entire earth-excavated canal with concrete, which would have lessened the grade and diminished the cross-sections. But this plan was changed and the base of the earth canal was built 66 feet wide and the slopes steeper than originally designed, in part because the work was done by steam shovel and the wider cut was cheaper.

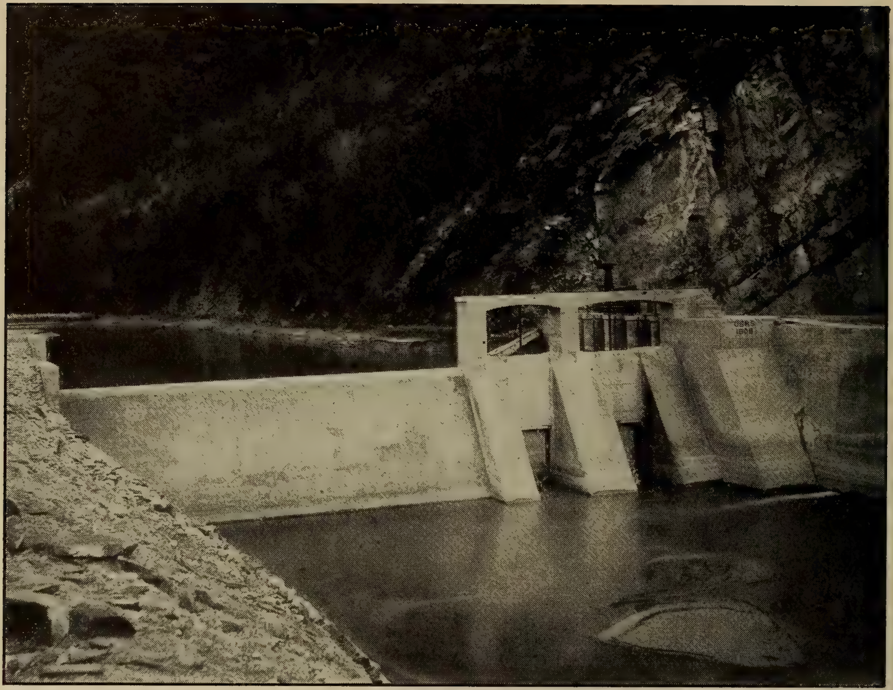
At the foot of the forebay another concrete dam, with racks and head gates, has been erected, and from this start the 7-foot penstocks, one of which has been installed for each water-wheel. This pipe line is 5,000 feet long, the upper 4,000 feet being of wooden stave construction and the lower 1,000 feet of riveted steel, leading down over a steep bluff to the power station, which is located on the river bank below, giving a working head of 378 feet. Water is carried into the power house, a fireproof building ample for four wheels and designed as about half of what will be erected when the entire portion of the company's development at this point shall have been called for. It is 77 by 181 feet in area, and when completed it will be 313 feet long and will contain eight generating units, each unit consisting of one 13,500-horse-power vertical reaction turbine built by Allis-Chalmers Company, with a 7,500-kilowatt, vertical 3-phase, 25-cycle generator, capable of developing 25 per cent. overload for



HEAD OF PENSTOCK AT THE POWER HOUSE OF THE STRAWBERRY VALLEY IRRIGATION SYSTEM, UTAH



POWER STATION ON THE STRAWBERRY VALLEY SYSTEM



DIVERSION DAM ON THE POWER CANAL TO THE STRAWBERRY VALLEY POWER STATION

three hours, mounted upon the turbine shaft. These turbine units are believed to be the most powerful ever put into service. The running portion of each wheel is 62 inches in diameter, and their velocity is remarkable for their size.

Among the recent water power developments on the Pacific Coast three groups are of especial interest, as they demonstrate the feasibility of successfully and efficiently supplying current for all kinds of work over hundreds of square miles of territory, the power being furnished from water-wheel and steam turbine-driven units located at widely different points. The first of these groups of water power development is the Pacific Gas and Electric Company, of San Francisco. This company has developed the largest distribution system in America. With more than 1,000 miles of 3-phase, 60-000-volt transmission lines they supply nearly 100,000 kilowatts for power and lighting—over an area approximately 200 miles north and south and 100 miles east and west—to one-half the population of California, in 153 cities and towns. Power is supplied from eleven water power houses and three steam power houses, some of them more than 300 miles apart.

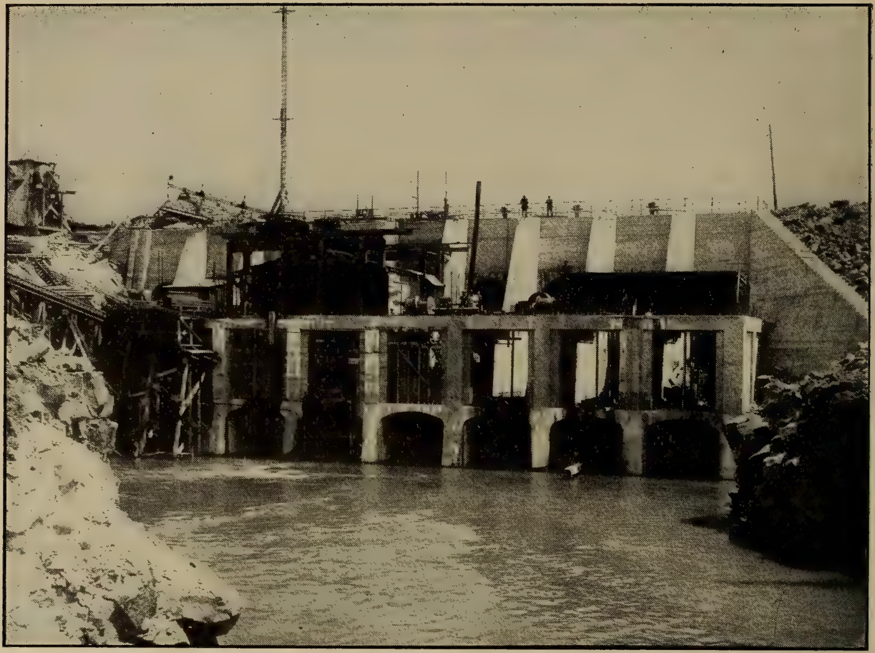
The largest power supply for this company is from the Feather River power house of the Great Western Power Company, located 154 miles north of Oakland. In this plant each generator is normally rated 10,000 kilowatts and is capable of 25 to 50 per cent. overload; the water head (430 feet) is among the highest under which the turbine type of wheel has yet been installed. The full load efficiency of the wheels is claimed to be 89 per cent., that of the generators 97.1 per cent., and that of the transformers 99 per cent., giving a total efficiency from water to the line, at 104,000 volts, of 85.4 per cent. With a transmission line loss of 13 per cent. and a step-down transformer efficiency of 99 per cent., the total delivered efficiency from water to the 60,000-volt distribution system, 154 miles from power house, is claimed to be 73.5 per cent. The Great Western Power Company's present development consists of four of these 10,000 kilowatt units. The company own rights available for development further up the river for approximately 200,000 kilowatts. The installation is the design of the General Electric Company.

The second of these groups is the Stanislaus power development, 130 miles east of San Francisco, operating over 104,000 volts double transmission line. The power house is situated in the middle of a bend in the canyon of the Stanislaus River, a sheer 1,500 feet below the canyon's rim. The water is brought 15 miles along the edge of the canyon in a large wooden flume to a point above the power house, and thence in steel pipes to four 7,500-kilowatt impulse water-wheels operating under a 1,500 foot-head.

The third group is comprised in the Kern River development, consisting of four 5,000-kilowatts water-wheel units, supplying power over an 80-mile line to Los Angeles at 80,000 volts. The current is generated from several water powers located on the canal and a steam turbine power house. It is an interesting fact that this power canal not only generates electric current by reason of its head of water, but forms the main water supply of Los Angeles. The main reason for constructing it was to give the city a permanent source of supply.

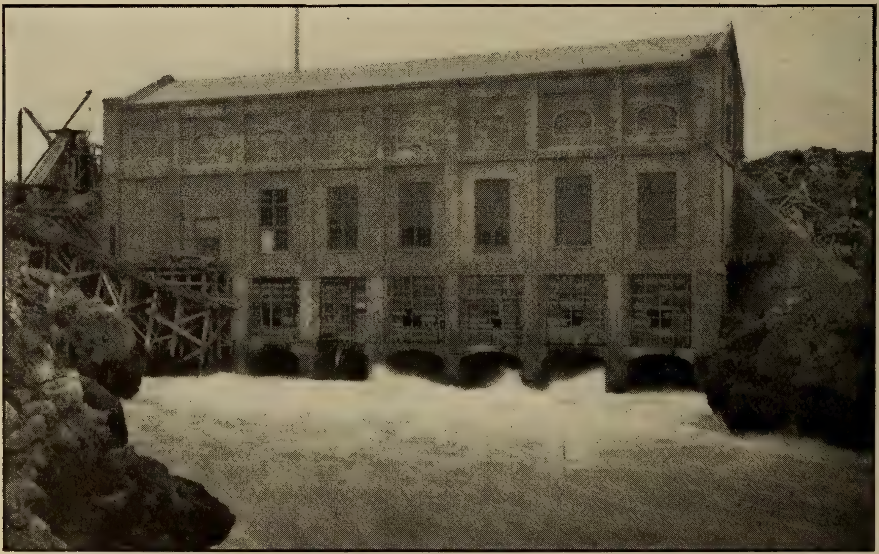
The industries of a number of Western cities depend upon hydro-electric plants for their power. Spokane is supplied from a 20,000-horse-power station 35 miles from the city. It also operates the mining machinery in the Cœur d'Alene region of Idaho, 60 miles distant. Butte, Mont., obtains power from a 150-mile transmission connecting it with a 40,000-horse-power station. This includes service to the thirteen copper mines around Butte. In connection with the reclamation service a num-

POWER HOUSE FOR ELECTRIC PUMPING IN CONNECTION WITH THE HUNTLEY RECLAMATION PROJECT IN MONTANA



HYDRO-ELECTRIC POWER STATION AT MININDOKA, PARTIALLY CONSTRUCTED

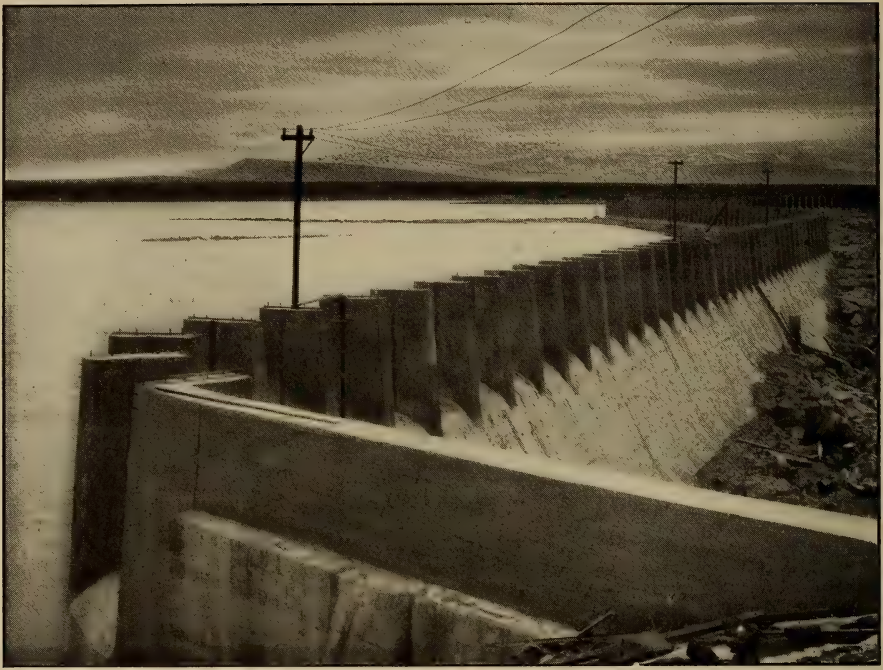
ber of hydro-electric plants are being completed or are in operation. Although the reclamation work was intended especially for irrigation, sixteen power sites have been found available for generating electric power. The most important is the Roosevelt, already described in a recent number of this magazine. This group of stations when completed will develop 10,500 horse-power for pumping irrigation wells in Arizona.



THE PERMANENT POWER HOUSE AT MININDOKA

TEMPORARY POWER HOUSE USED IN CONSTRUCTION WORK ON THE MININDOKA PLANT

INTERIOR OF MININDOKA POWER HOUSE, SHOWING ELECTRIC GENERATORS



ENTRANCE TO POWER CANAL AT THE MININDOKA DAM

The power installation is of the General Electric type. Other developments are the Uncompahgre, already described in this article; the Minidoka and Boise, in Idaho; Huntley in Montana, Truckee-Carson in Nevada, Klamath in Oregon, and four in Washington, aggregating 17,000 horse-power, the largest, the Wapato, generating 9,000, which is next in importance to Roosevelt.

The Minidoka plant is located on the Snake River, 6 miles from the town of Minidoka. The power house is of reinforced concrete, 50 x 150 feet in plan, and 85 feet high. It contains turbine and generator floor and galleries. The hydraulic machinery consists of five vertical turbines of radial and axial downward-flow type, rated at 2,000 horse-power each, when using 425 second-feet of water at 46 feet head. There are also two exciter turbines of the vertical type, rated at 180 horse-power. The electric generating apparatus consists of five 200-kilowatt, 2,300-volt, 3-phase vertical alternators of the revolving field type and two exciters 120 kilowatts, 125-volt compound round vertical type. An air-cooled, 3-phase, 60-cycle transformer stepping the voltage up to 33,000 volts is provided for each alternator.

The current to the pumping stations is carried over a transmission line 21 miles in length. The current for industrial and commercial purposes for the three towns of Heyburn, Rupert and Burley is delivered under contract from the power house at the Minidoka dam, and light, heat and power are furnished.

The pioneer plant for supplying current in southern Asia has been installed by the General Electric Company. It is utilized to operate mining machinery in the gold fields of Kolar, with about 4,000 horse-power obtained from Cauvery Falls. At a point 2 miles above the falls and above the swiftly-descending rapids a low diverting dam 4.2 feet in height and 390 feet in length was built of granite masonry on a river bed of hard trap rock. This dam was built for the express purpose of diverting the entire supply of water to the channels during low water periods. The entrance to the two channels is equipped with suitable gates for regulating the flow of water, and, in addition, with a scouring sluice for preventing an undue accumulation of silt in front of the channel openings. There are two parallel channels which follow the natural contour of the country, so that, although the distance down the river from head works to power house is but 2.65 miles the channels are 3.375 miles in length. These two channels, when filled to a depth of 6.3 feet, pass 560 cubic feet of water per second, which quantity is sufficient to develop 18,750 horse-power at the turbine shafts.

The two channels terminate in a forebay which is built in two sections, one for the original installation of 6,000 horse-power and the other for the first extension of 5,000 horse-power. Recently a second extension has been made, increasing the capacity of the plant by 2,000 horse-power and making a total of 13,000 installed electrical horse-power in generators.

The turbines were built by Messrs. Escher-Wyss & Co., of Zurich, each turbine having a capacity of 1,250 horse-power at 300 revolutions per minute, with a water consumption of 37½ cubic feet per second. The generating station is equipped with three turbine-driven and two motor-driven exciters, each of 75 kilowatts capacity. The generators consist of eleven 720 kilowatts units, and one 1,500 kilowatts units, all of which are operated at 2,173 volts.

The distance of transmission is 92 miles. During the third installation period a third circuit was built.

On the several mining properties of the Kolar gold field 9,000 horse-power from the Cauvery supply is employed in general mining operations, including the driving of air compressors, mills, stone breakers, workshops, cyanide works, pumps and electrical hoists. The hoists are both above and below ground and are used in sizes up to 400 horse-power. These hoists are driven by 3,000-volt, 3-phase induction motors, controlled by resistance in the rotor circuit.

The electrical engineer has also penetrated into Kashmir. Here the Jhelum River has been made the generator of electric power to deepen its own channel, thereby preventing it from overflowing 200,000 acres of land and reclaiming this for agriculture. The engineering plan is a novel idea, but has had very successful results.

Since coal is not available in Kashmir, and since the site where the dredging was to be done is nearly 200 miles from the nearest railroad station, electric energy was decided upon for the driving of the dredges. The river gives an ample supply of water throughout the year, and a hydro-electric plant was therefore erected for supplying the power. The plant was built with an available working head of approximately 400 feet, and an ultimate capacity of 20,000 horse-power, of which but 5,400 horse-power is at present utilized. After a careful consideration of the topographical conditions, it seemed advisable to construct a canal 6½ miles long. Four Doble impulse water-wheel units, with automatic oil pressure governors, are installed, while tail races and additional transformer compartments for four more units of similar capacity have been built. At the upper end of the tail races, where the jet discharges almost perpendicularly downwards, flat steel plates are set in the concrete. Each unit is guaranteed to deliver 1,765 horse-power to the shaft at 500 revolutions per minute under an effective head of 400 feet. The generator plant consists of four General Electric 3-phase, 2,300-volt revolving field generators and two 6-pole, 150-kilowatts, 125-volt exciters. The exciters are direct connected to 250 horse-power individual water-wheels of the impulse type, located in the middle of the station below the switchboard gallery.

# ENGINE-TESTING BRAKES

By W. D. Wansbrough

THE engine-testing brake, or, more correctly, the absorption dynamometer (the name, not the instrument, being of Greek origin), in one form or another is an indispensable adjunct to every modern engine factory. To keep abreast of the times it is not sufficient to turn out a standard series of steam, gas or oil engines without a searching investigation of the capacity and economy of each individual machine. The up-to-date engine maker cannot announce loftily, like Matthew Boulton of old, "We sell here what every man desires—power." This was appropriate enough and a very justifiable boast at the Soho Foundry a century and a half ago, but it is a little too vague for to-day. The present-day purchaser is an exacting individual, who will have his pound of flesh, and is, moreover, exceedingly difficult to secure. It behooves us, therefore, to be fully conversant with our limitations, lest haply we put forth pretensions which we cannot make good. We must measure our power visibly, and in such a manner that there can be no dispute.

Now, there are many ways of effecting this, and it may be profitable to discuss some of the methods in use.

We have in Fig. 1 the primitive brake, consisting of a plank, a brick and a brake-block, acted upon by the weight *W*. Of this apparatus the weight *W* is the only part worth preserving. All the same, from this elementary contrivance, which, of course, has no pretensions to be a power measurer in any sense of the word, but only a means of loading the engine, has been evolved a remarkably clever adaptation of the idea known as the Sellers Portable Dynamometer.

In Fig. 1, with the flywheel revolving in the direction of the arrow, there is a strong tendency to draw the whole apparatus towards the left, rendering it necessary to keep the fulcrum very low to avoid the risk of its upsetting, and the consequent release of the engine from its load without notice. In the purely diagrammatic sketch in Fig. 2 this objectionable peculiarity has been turned to good account. The brake-block has been mounted upon rollers, the plank is replaced by a cast-iron beam with a fixed fulcrum, and a strong spiral spring is introduced. It is obvious that we have here a means of measuring the tangential drag of the wheel upon the brake-block. The weight can be moved along the beam and the load adjusted to any nicety, rapid and measured changes in the load being easily made. In practice the pull is measured upon a graduated dial plate which is marked in pounds, and this reading is the exact equivalent to the weight *W* in Figs. 4, 5, 7 and 10, following, neither the friction of the rollers nor the varying frictional resistance between the wheel and the brake-block impairing

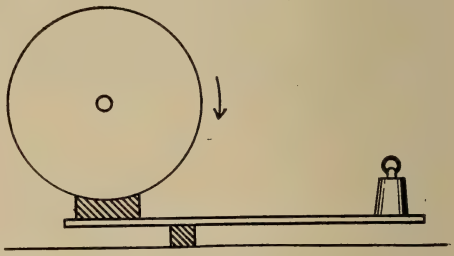


FIG. 1.—PRIMITIVE BRAKE

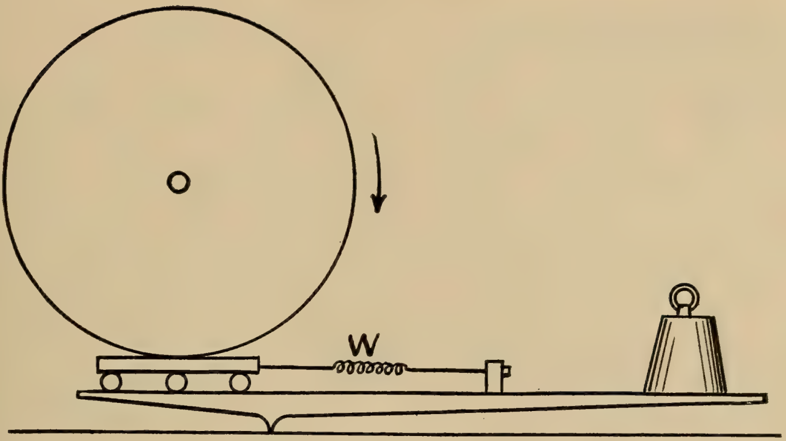


FIG. 2.—SCHEME OF SELLERS DYNAMOMETER

the accuracy in the slightest degree. We have not any practical experience of this brake, but the makers, Messrs. Dobbie, McInnes, Ltd., Glasgow, claim that as much as 30 brake-horsepower can be absorbed for an hour at a time without undue heating of the flywheel rim.

Fig. 4 shows the original form of Prony brake, consisting of a pair of brake-blocks embracing a small pulley on the engine shaft, the weight *W* being generally substituted by a spring balance.

The writer, many years ago in Norway, had the privilege of seeing this type of brake in use and can confidently recommend it to any one on the lookout for an exciting time. It is necessary, of course, for the lever to remain horizontal, or nearly so, and the difficulty is that its continued tendency to fall from that position, owing to the wear of the brake-blocks or a spot of oil or water occurring on the pulley, has to be corrected by tightening up the wing-nuts. The slightest excess in this direction would apparently result in the weight being hurled into space like a stone from a catapult. This tendency is resisted by a safety chain, which is continually being called into action. As a matter of fact, it is practically hopeless to get accurate results from this brake. Assuming the lever to be horizontal and

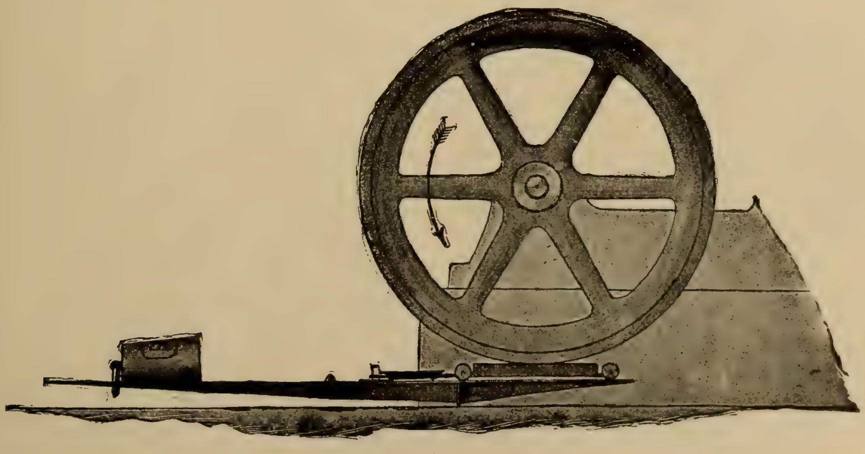


FIG. 3.—SELLERS DYNAMOMETER IN USE

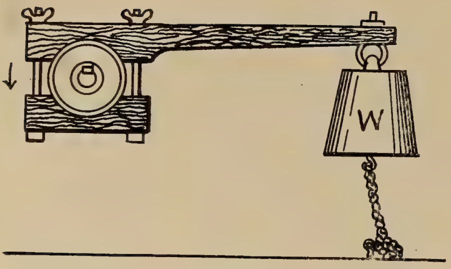


FIG. 4.—ORIGINAL PRONY BRAKE

of length $L$, we have, in effect, the condition of a weight $W$ being wound up on a drum of diameter 2 $L$ feet at $R$ revolutions per minute. Hence the brake-horse-power exerted will be the product of the effective circumference into the number of revolutions per minute into the weight divided by 33,000, or

$$\text{B.H.P.} = \frac{2\pi LRW}{33{,}000} = .0001904\,LRW.$$

As it is usually more convenient in practice to express the length $L$ in inches rather than in feet, we use 1/12th of the constant above, or B. H. P. $= .00001587\ L\ R\ W$, and the weight $W$ in pounds for a given B. H. P. is

$$W = \frac{63000\,B.\,H.\,P.}{L\,R}$$

while for a given B. H. P. and weight the length $L$ is (in inches)

$$L = \frac{63000 \times B.\,H.\,P.}{R\,W}$$

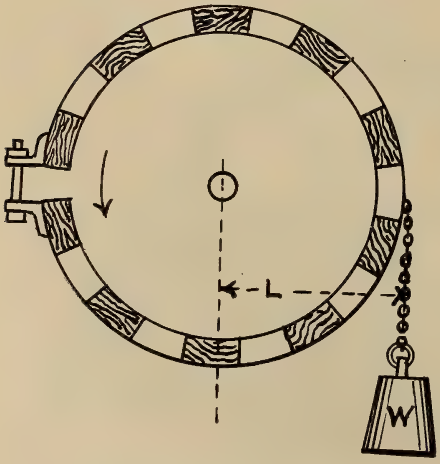


FIG. 5.—FRICTION BRAKE ON FLY-WHEEL

This very elementary formula applies to all the brakes under notice, and is, indeed, general for all brakes which hold the weight suspended.

In Fig. 5 the small pulley is suppressed altogether and the engine's own flywheel is utilized, being encircled by a ring of brake-blocks within an iron band. This brake calls for little comment. It has the disadvantage of being heavy and clumsy and is not easily adapted to different sizes of flywheel. It is, however, a vast advance on Fig. 3, in that it is reasonably possible to keep the weight suspended without incessant attention to the adjusting screw.

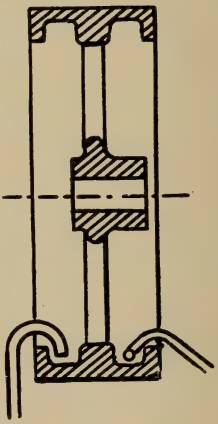


FIG. 6.—WATER COOLING FOR FLY-WHEEL BRAKE

It will be realized also that the heat generated between brake-blocks and flywheel rim by the friction at any but very light loads is very considerable and would speedily result in the destruction of the wheel unless provision were made for carrying it away. Many accidents have, in fact, occurred by the breaking away of the rim from the spokes through the expansion of the former from this cause. A water-channeled wheel, Fig. 6, should therefore be employed for any test of more than a few minutes' duration, having a water-pipe fixed

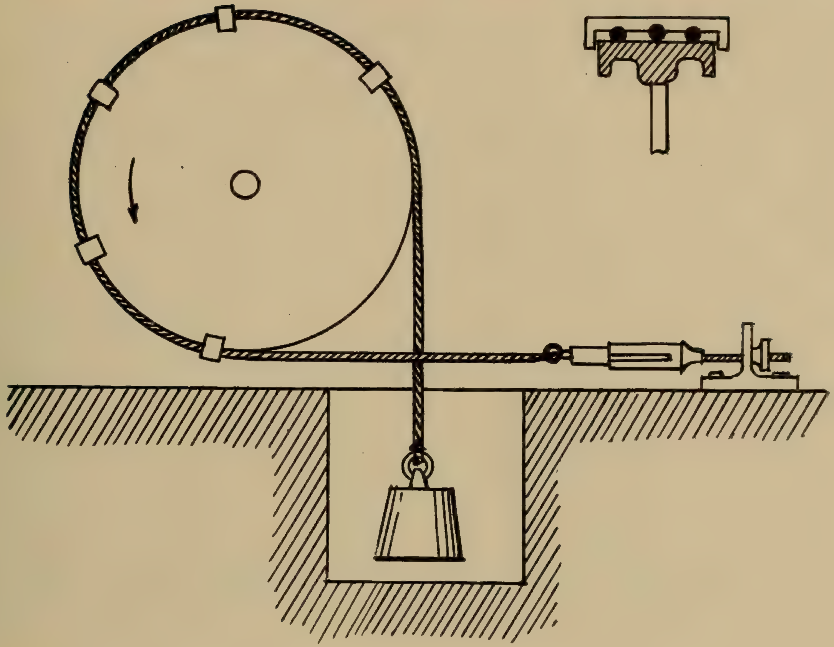


FIG. 7.—LORD KELVIN'S ROPE BRAKE

for feeding the water in, pointing away from the direction of rotation, and a scoop, or short pipe, facing the rotation, for "peeling" the water out. In this way a test of many hours' duration can be conducted in comfort and with safety. It should not be forgotten, however, that the weight of the revolving mass of water at high speeds adds considerably to the bursting stresses in the flywheel. The rim section, therefore, should be proportioned accordingly.

Tracing the evolution of the testing brake we come, as is not unusual in mechanical matters, to a comparative state of perfection in an apparatus of singular simplicity. The rope-brake, Fig. 7, stated to have been first used by the late Sir William Thomson (Lord Kelvin) in his deep-sea sounding machine, consists in principle of one or more ropes passing completely or partially round the periphery of the wheel and registering by the difference between the readings *X* of the spring balance and the weight shown the net load in suspension.

Though at first sight brake-blocks seem to be employed, the ropes alone are in contact with the wheel, the apparent brake-blocks being only wood clips to keep the ropes in position on the rim. Apart from the simplicity, adaptability and cheapness of the rope-brake, it has in a prevailing degree the advantage of being well ventilated. A glance at Fig. 5 will illustrate this by comparison. There the rim of the wheel is encircled by a broad iron band, while quite one-half of the periphery is in actual contact with the wood blocks. In the rope-brake almost the whole of the rim is freely exposed to the air. The effect of this is realized in the fact that the water-cooled rim may be safely dispensed with, except for long runs.

It may be here observed that while in text-book illustrations of this form of brake the spring balance is usually shown attached to an overhead beam, long experience in actual use has demonstrated the superior advantages of a horizontal attachment, as in

Fig. 7. There is more than a little risk of the ropes fouling each other with disastrous consequences when the vertical position is used and the ropes completely encircle the wheel. With large powers, or high speeds, it is also very necessary to be able to "let go" and drop the weights at a moment's notice; and instead of the spring-balance being directly attached to the floor bracket, as shown, the bracket should be put some feet further away and a pair of light Weston's blocks and chain-tackle interposed. Any tendency of the weights to rise is then quickly compensated and the man in charge is well away from possible danger. Care is necessary in the use of all brakes, and no unnecessary risks should be run.

Within the last few years the Froude Water Dynamometer, originally devised by the late Mr. William Froude in connection with his experience on the propulsion of ships, has been developed upon a commercial scale by Messrs. Heenan & Froude, Ltd., of Manchester, to whom we are indebted for the illustrations, and has come into extensive use as a safe, ready and accurate instrument for measuring the power given out by prime movers of every kind.

The original idea was, no doubt, taken from the ordinary centrifugal pump, which obviously might be used as a roughly approximate means of measuring power by varying the height of a lift, or, what would come to the same thing, throttling the delivery by a sluice valve, thus "inserting resistance." Such a machine, however, would be totally wanting in the essential characteristics of a dynamometer.

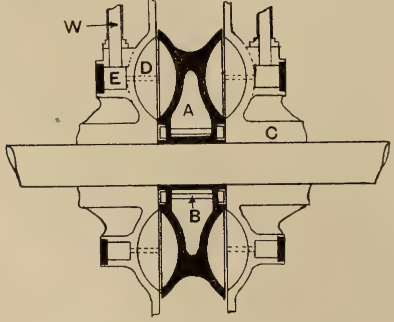


FIG. 8.—FROUDE WATER BRAKE

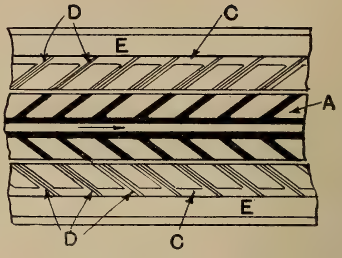


FIG. 9.—ARRANGEMENT OF CUPS IN FROUDE DYNAMOMETER

Fig. 8 shows a general section of the Froude Dynamometer, which consists of a rotator mounted on a shaft, which is direct-coupled to that of the engine or motor to be tested. This rotator is two-faced and revolves within a casing mounted upon rollers. To this casing is attached the brake-arm, or lever, carrying at its outer extremity the weight to be held in suspension.

On the faces of the rotator and of the casing are formed cups, those on the former being so shaped as to look forward in the direction of rotation and to oppose those on the casing, which look backward.

The machine being supplied with water, the engine is set in motion, and a resistance, tending to lift the brake-arm, is immediately set up. The water contained in the cups of the rotator is delivered from their outer surface and, by the action of centrifugal force, is thrown with considerable force against the upper part of the fixed cups in the casing. The water then circulates round the outer surface of the fixed cups and enters the bottom edge of the moving cups with an increased velocity, due partly to the velocity of its delivery from the fixed cups and partly to the velocity with which the cups of the rotator meet the jet as it is delivered from the fixed cups. Thus a whirlpool or vortex motion is set up in each cup, the power required to

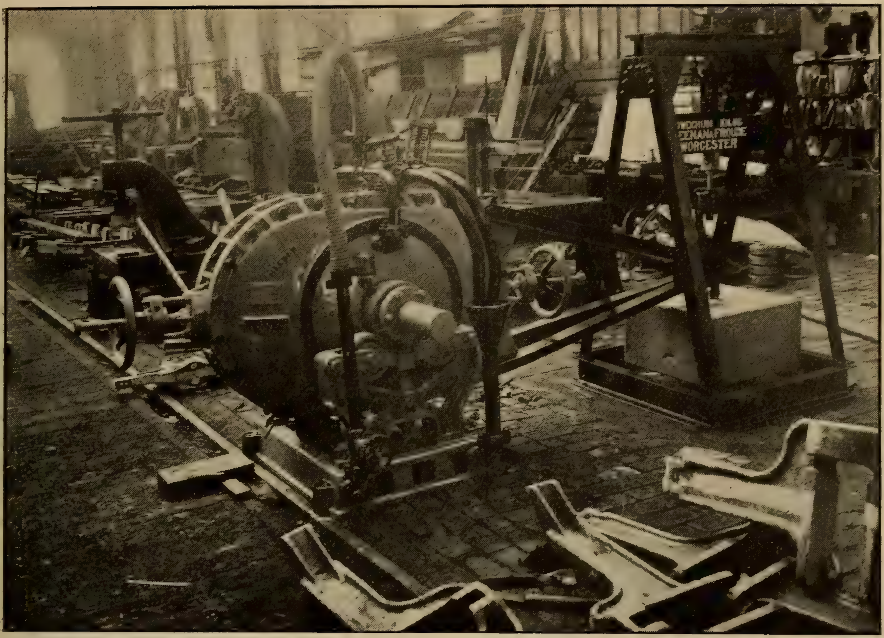


FIG. 10.—FROUDE WATER DYNAMOMETER IN USE

drive the rotator being mainly expended in keeping this going. The whole of the power exerted being converted into friction, it is necessary to introduce a continual supply of cold water, and it is interesting to note here that the range of temperature from inlet to outlet and the quantity of water used afford an accurate measure of the power, thus:

$$\frac{33{,}000 \text{ H. P.} \times 60}{778\,(T - t)} = \text{pounds per hour,}$$

where $T$ is the outlet temperature of the water and $t$ its inlet temperature. The factor 778 will be recognized as Joule's equivalent; and, as a matter of fact, the most recent determination of this constant was deduced by Prof. Osborne Reynolds and Mr. Morley from observations of the machine we are now describing. The formulæ for calculating the horse-power absorbed are exactly those for any other weight suspension brake (page 412, *ante*). The only possible error which could arise would be due to the friction on the rollers carrying the casing, but as the rollers are themselves mounted upon ball bearings, the retardation from this cause through the very small arc of lever motion is not only "practically" but absolutely negligible. It will be understood, of course, that any friction between the brake-shaft and the journals reacts upon the casing, and thus no error is introduced on this account.

The Froude Dynamometer is (1) accurate in its determinations, (2) capable of use for a test of any duration, as the heat generated is carried away as fast as it is produced; (3) maintains a constant resistance for any length of time, from the maximum downwards to any fraction of the total desired at any particular speed; (4) is applicable to a wide range of powers at varying speeds; (5) it is comparatively small and compact; for instance, a 30-inch machine is capable of dealing with 1,000 horse-power at 300 revolutions per minute, and (6) it is safe in use. The dangers of the friction brake, either by the flinging over of the weight or by the bursting of the fly-wheel, are absolutely eliminated.

# THE GREAT TRANSFORMATION

By Henry Harrison Suplee

## V.—THE TRANSFORMATION IN GOVERNMENT

IN a document which is the basis of the government of one of the great nations of the world it is set forth that: "governments derive their just powers from the consent of the governed," and this proposition really forms the basis of most of what are called constitutional governments.

As a matter of fact, modern governments are mainly based upon the results of attempts, more or less successful, of the "governed," that is, of the great majority, to take from previous arbitrary rulers as much as possible of their power and to keep it in their own hands.

The crude governments of savage tribes are nearly all despotic methods of individual rule, a chief holding absolute power until death or deposition places the power in the hands of a successor equally arbitrary and equally irresponsible.

The gradual development from this state of affairs into what is now termed "constitutional" government, and its further progress along the same lines, have been largely due to the extension of the control of the forces of Nature into the hands of the general populace. When a strong individual will, backed by a few chosen and powerful associates, was able, by the combination of physical strength and a certain amount of keen cunning, to dominate a large but ignorant and powerless populace, it was natural that a despotic government should result. As the great majority gradually came into the possession of greater powers, such as were placed in their hands by improved weapons, better mental development, and greater realization of their strength, the ruling power became tempered as a result of numerous experiences; and when, as has occurred repeatedly in recent centuries, the people found that they had only to take the control to overthrow the existing government, the experiment was repeatedly tried, with degrees of success which the pages of history amply record. It is not intended here to discuss the right or wrong of these events, nor to advocate any particular theory of government, but only to indicate what may be expected as a result of the placing still another powerful instrument in the hands of the people, one comparable to the introduction of firearms in the period covered between the fifteenth and seventeenth centuries.

The fact that property is limited to that which one is able to defend may be extended to a statement that governments can rule only when they are able to enforce their decrees. When the so-called executive branch of a government finds that it cannot carry out the enactments of the legislative branch, and when the judiciary realizes that its judgments pass unheeded it is evident that such elements of government have practically ceased to exist. It follows that when the power of the individual becomes as great as that of the government, the latter will become almost entirely dependent upon the willingness of the people to obey.

Every successful revolution is an example of such a condition of affairs. King Charles I in the Council of the Star Chamber and King Charles I seated before the High Court of Parliament in Westminster Hall were practically two different persons, solely because of the shifting of the power to enforce their rulings, and the same is true to a greater or less degree with every change in the ability to *do* things.

It follows that the general introduction of the ability to come and go at will, without let or hindrance, may place in the hands of the governed so much greater power than formerly, that they will gradually exert that power, mainly by abstracting it from the present governing bodies. This does not indicate that any revolutionary action may be anticipated. In fact, it is altogether probable that whatever changes do come will progress with the general rate of individual appreciation and thus be very little noticed by those who are floating along with the same current.

It has already been shown that the ease with which frontiers may be passed at any point by the man who travels through the air will render any system of customs examination upon entry practically futile, and the only method of insuring the collection of such imposts, except in the cases of unusually heavy or bulky articles, will be by subsequent investigation and enforcement. Such methods are already in force in countries where high tariff duties are imposed, but the very nature of the system renders it repugnant even in the limited number of instances in which it has been found necessary to carry it out; and it is extremely improbable that any government which should attempt to enforce a general method of local searches over an entire country could expect to remain long in power. By methods entirely peaceful, and therefore all the more effective, such a system would doubtless be relegated to the limbo to which it has been preceded by hearth duties, window taxes and ship money.

In this connection it may be of interest to suggest, in passing, that the inability to raise sufficient revenue by customs, and the general increase in individual freedom following upon the uncontrolled opening of the third dimension, may render it ultimately necessary for all taxation to be placed upon real estate, as being the only thing which can be positively located, so that the so-called land-tax system may come into general effect, not because of any especial inherent merit, but rather by a process of elimination. This, however, is a matter which may be left to adjust itself, and in any case it will doubtless be determined by the subsequent development of the command of natural forces and not by reason of any exercise of persuasion.

It has been suggested that the ease with which any one may become possessed of a machine which will enable him to go at will to any point through the air will give an enormous power to criminals in the conduct of their nefarious designs. This is doubtless true, and there are many precedents for such a conclusion. Other scientific developments have been seized upon by evil-disposed persons, and much harm has followed. The use of firearms has enabled many murders to be committed, and the employment of high explosives has extended the scope of the bank burglar; while accounts of highway robberies conducted with the aid of automobiles are not unknown. Until the recent change in the government of Turkey, no telephones were permitted in the empire, because the Government held that any means which enabled subjects to communicate freely with each other without the espionage possible in the mails might endanger the existence of the Government. Since the more despotic form of government has been replaced by one of a later date, however, arrangements have been made for the entrance of the telephone into the Turkish Empire in a manner similar to that which has been found entirely safe in other parts of the world. Any source of power in Nature may be abused, and it is not to be supposed that the machine which has provided a new, powerful, and wholly personal method of locomotion will be free from such abuse. One of the functions of government is to maintain order, and if the introduction of aerial navigation may be followed by a new method of evildoing it will doubtless become one of the changed details of government to cope with the fact. It is possible that the great difficulty of catching and punishing evil doers who may use the new adjunct to their designs will result in an altogether changed method of dealing with crime. The ordinary plan, at the present time, is to wait until a crime has been committed and then to employ skilled detectives to catch the offender and to set in motion the cumbrous machinery of the law to punish him. Somehow this method does not seem to have been attended with very brilliant results, and it is possible that with increasing impracticability of catching anybody it will have to be abandoned altogether.

If we accept an idea which is not without advocates already, and consider crime as a sort of disease, it is possible that we may follow methods which have been employed with surprising success in treating other forms of disease; and as preventive medicine has succeeded in lowering the death rate, we may find that other forms of preventive action may lower the crime rate. Certainly it will be incumbent upon governments, if they are to do any governing at all, to avoid throwing up their hands and proclaiming their helplessness. Methods similar to those which have prevented thousands of deaths from fever and malaria at the Isthmus of Panama may be discovered for preventing deaths at the hands of degenerate human beings, and possibly the only thing needed for the development of such methods will be the utter breakdown of the old plan of trying to keep one man from committing a crime by punishing some other man. Just what such methods may be cannot be determined at the present time, but if the expenditures incurred in maintaining detective departments were diverted to the extermination of slums and criminal quarters in cities, and in the dispersion of the hordes of ignorant aliens from congested localities into the wholesome country, doubtless much unenacted crime would be prevented. One of the inevitable results of the spread of population, due to new and independent methods of transport, would be the extermination of breeding places of crime, just as the breeding places of disease-carrying mosquitoes have been removed, so that the new order of things would aid in working the cure of the social disease.

It is evident that all the changes which may thus far be foreseen as to the influence of general aerial transport upon government will act to diminish the importance of the administration. As we have seen that the influence of the opening of the freedom of the air tends toward decentralization in commerce, warfare and residence, so it appears to act in connection with governmental activities and powers. When control over boundaries has to be abandoned, when immigration cannot be regulated, and when the handling of crime has to be referred to scientific methods of prevention and cure, it is apparent that the machinery of government may be enormously simplified.

Probably it will be extended along other lines, especially in connection with scientific research and investigation, and already the conduct of such work by official bodies has been increased in scope in various countries. If, as seems probable, the development of general aerial transport will be followed by the abandonment of the crude methods of destructive warfare as a means of settling national differences, another extensive function of government will disappear, or become reduced to a mere matter of policing the disorderly conduct of semi-civilized peoples. The whole tendency will probably be toward a very simple system, ultimately becoming international, or rather universal, since national limitations cannot long be permanently maintained under the changed conditions. The desire of individuals to hold official positions will also diminish under such a state of affairs, and thus the conduct of government, instead of being a widely sought object, may ultimately be considered as rather a minor duty, to be effected with as moderate a degree of publicity and ostentation as possible, and not so desirable as many other and more readily attainable objects.

As matters stand at the present time much of the complication of government work follows because of the necessity of being prepared for war, and the maintenance and administration of armies and navies form a very large proportion of the entire management of a country.

With the elimination of boundaries and of a large portion of national distinctions it is probable that the causes for international conflicts will disappear, and that the existing systems of government in various parts of the world will become so modified as to cover details of local affairs, while some "federation of the world" will arise to control matters of world-wide character. Already some indications of such a combination are appearing in connection with international agreements concerning arbitration of national disputes, and the extent to which international commercial and financial interrelations are preponderating in the maintenance of peace is being widely appreciated.

When to such forces for international comity there is added the still broader influence of universal individual travel through the space above the various countries, the necessity for such a primitive thing as combat about differences of opinion or policy will become as remote as the duel has already become in Great Britain or the United States.

There is another feature which is almost certain to result as a consequence of the extension which aerial navigation is giving to freedom of movement; one which follows naturally upon the obliteration of national frontiers and boundaries. Already the development of transport systems has contributed immensely to a sort a renewed "wandering of nations," and the extent to which a new country, such as the United States, for example, becomes a "melting pot" for the assimilation of people of different races can be appreciated only by those who have actually studied it at first hand. The automobile has already added to this modification in the local ideas which have until recently been emphasized in the thoughts of men, so that there is appearing a gradual wearing down of the idea of attachment to any one locality on the surface of the earth, and a general development of the cosmopolitan idea, which brings to every man who has traveled much the realization of the feeling that he is a citizen of the world. It is a trite expression to say: "How small this world is!" when one meets friends at a great distance from home, but the world has been growing smaller every decade, with the increase in the speed and number of trains and steamships, and with the multiplication of motor cars. When the machine in the air becomes popularized as the automobile has already become, the attachment to locality will become further loosened, and the feeling of patriotism become almost synonymous with provincialism.

The natural tendency of mankind is to judge a new thing by existing standards, and to fail to recognize the extent to which the development of new ideas and apparatus may change those standards. As a matter of fact our standards are themselves nearly all the outgrowth of the conditions with which they are associated, and as the conditions are altered the standards become modified. This is readily seen in connection with such an elementary idea as that of a "day's journey," for example, which formerly constituted a fairly definite idea of distance, but which is now hopelessly obsolete. In like manner the limitations which have, until now, been experienced in moving about upon the surface of the earth, involving the use of streets and roads, and including the restraint of trespass upon private property, have entered so deeply into the idea of government that it is extremely natural to consider the relations of the new apparatus to a government which is the outgrowth of a very old and inflexible set of limitations, limitations which are undoubtedly to be removed to a very great extent. It must therefore be kept always in mind that the government which is to be considered in connection with the general use of the third dimension is to be a very different kind of government from that to which we are at present accustomed. Broadly, it will have to be based upon that principle of freedom which accepts the right of every man to do as he pleases without interfering with the right of any other man to do as *he* pleases. Without any government this would lead almost immediately to the mediæval "right of private warfare," a right which really does exist in many departments of commercial and industrial affairs at the present time almost as extensively as it once did among feudal barons. With a government, of which the principal function is to assure to each person his right to "life, liberty, and the pursuit of happiness," leaving the newly-acquired freedom of the third dimension to work out its own methods of administration, it will be seen that a transformation of standards must necessarily follow, and such a change should be studied in advance, as far as possible, upon its own merits, and not upon preconceived ideas originating in existing and passing relations.

Reviewing, then, the changes in the ideas and constitution of government, as influenced by the general introduction of absolute freedom of traverse through the air, it seems as if the ultimate result would be to weaken very greatly the power of centralized governments, and limit their activities very largely to contributions to knowledge by increased work of such departments as those relating to commerce, manufactures, agricultures and applied science, and to cause the hitherto predominating departments of war, navy, State, etc., to assume very subordinate places. Armies and navies, relegated to minor positions, and wholly lacking in any social importance, would become rather national police departments, having the duties of keeping in order such disorderly and semi-civilized peoples as may have lagged behind in the general advance. The obliteration of international boundaries, which must follow upon the transfer of general movement to the air, would naturally carry with it nearly all occasion for international discussions of every sort, so that the multitudinous circumlocutions of embassies and consulates would fade away without being missed; passing on to keep company with the army of custom house officers, inspectors and factotums.

Probably the one department of government, as at present understood, which would be first advanced under the new state of things would be that devoted to the transmission of intelligence, the postoffice. At the present time the transfer of communications, publications and general intelligence, while nominally a department of the government, is inextricably bound up with the private transportation organizations controlling existing methods of transport. With the development of freedom and independence of communication through the air there would appear to come a release from this state of affairs, and the aerial post seems to be the first form of utilization of the new contribution to civilization. The nearest approach to this modification which we now have appears in the pneumatic tube, which has already been applied to the rapid transport of mail matter between postoffices. With the active development of aviation, however, we may expect to see, as one of the first manifestations, the conversion of the roofs of our postoffice buildings into points of departure and landing of the machines which will act to carry the mails directly to their destinations, regardless of existing and obsolete apparatus. In this connection it would appear that any attempts to restrict the independent transport of letters and similar material would become as futile as the idea of a control of imports, so that the carriage of the mails would become as open to the beneficent influences of unrestricted competition as governments appear to desire to render other departments of commerce.

Centralized regulation of commercial affairs by government would necessarily be modified by the general development of aerial commerce, apart from the disintegration of any system of import duties, since the ability to choose any route for transport, and to carry goods directly from shipper to consignee without the intervention of any public or official terminus or warehouse, and with no opportunity for inspection, would make any form of government supervision almost impracticable. It would seem, therefore, that what has of late become a prominent feature in government may become of minor importance by reason of the new development in methods of transport and communication.

With military affairs, customs service, and regulation of commerce minimized, or almost entirely removed, as a consequence of the development of aviation, it will be seen that the functions of government must become very materially reduced. Instead of governing, as understood in the older sense of the term, the administration of the future may be expected to become rather a form of superior guidance to progress, furnishing such information as may be attainable only by the broader opportunities of official investigation, conducting such useful public works as may be impracticable under individual or corporate methods, and furnishing such measure of police protection and crime prevention as the developing methods of science may indicate. Apart from these and similar activities, the form of government which seems probable under the coming transformation will leave to the individual the greatest possible measure of personal and commercial freedom, simply because the development of the freedom of the air will take away from any government the power to do anything else.

(To be Continued.)

# ALTERNATING STRESS TESTING MACHINES

By C. A. M. Smith

As each year goes by, a certain amount of knowledge concerning the properties of materials accumulates; this knowledge opens out further possibilities of research and stimulates other investigators. In engineering work it sometimes happens that many investigators are engaged upon the attempt to solve a certain problem, and for years it appears that no progress is being made. Quite suddenly we are made aware of some remarkable development, and we are apt to assume that it was the result of an inspiration—a flash of genius. If we could pierce behind the veil of the laboratories and the studies of men who possess research instincts, we should probably find that the new advance was not at all the thing of a day. There are few roads cut through the forest of the unknown-in-science by the fairy wand; much labour by many willing workers is required to fell the trees and clear the undergrowth. It is not given to everyone to live to see the road finished; it is enough to have lent a hand. When the others who follow see the clear way, they forget the bushes and the patience of the pioneers.

Some of the paths are long, and at times it appears that but little progress is being made towards the end. Yet the unexpected comes at last. Sometimes the end is wonderful—a thing quite beyond the fondest hopes of the workers. Emerson, in one of his essays, says that a man never rises so high as when he knows not whither he goes. It has happened, in the long romantic history of science, that a physical discovery, such as that of latent heat, has rendered possible a practical benefaction to mankind, such as the steam engine. It is very doubtful whether Dr. Black was at all conscious of the possibilities to manufacturers of his discovery of latent heat. It is quite improbable that Prof. Osborne Reynolds foresaw that his researches on the flow of steam through nozzles would lead to the type of prime mover used at Lot's Road power station and the source of power of our Dreadnoughts.

The work of testing the materials of construction is very largely of a practical nature. Many people imagine that the experiments in college laboratories have one purpose only—viz., to enable students to understand how the various metals and alloys behave under different methods of loading. But beyond that class of work there is something which, though hardly so apparent to the general body of engineers, is none the less real and equally useful. The staffs of the colleges and the graduates attempt to do the pioneer work, to cut out a few paces in the path through the forest of the unknown. It is the kind of occupation which has a real and peculiar fascination for those who engage upon it. There is a great probability that there will be no reward, but there is always the satisfaction and the exhilaration of the struggle with Nature.

Of late years several investigators have attacked the problems arising out of the phenomena of alternating stress. The experiments are lengthy and somewhat expensive, and, up to the present, the results obtained would be considered disappointing by those who are impatient. Yet we are pos-

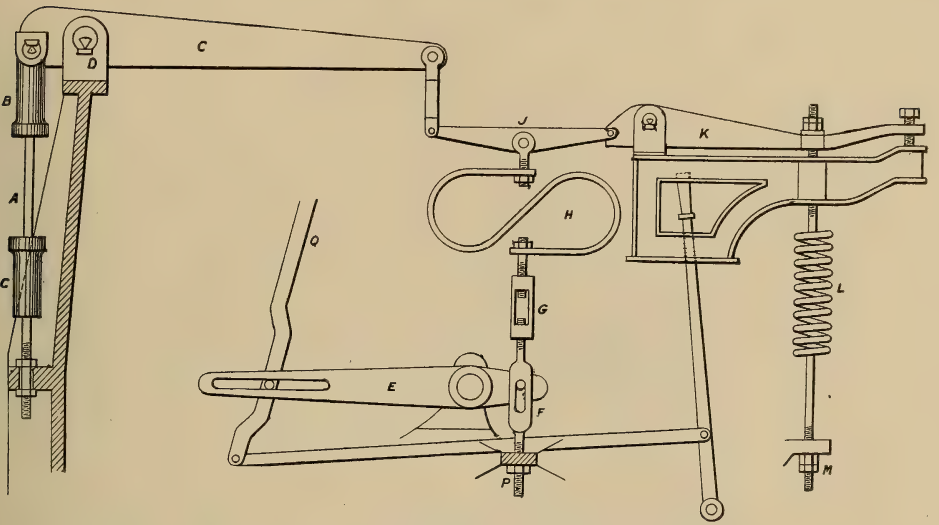


FIG. 1.—DIAGRAMMATIC SKETCH OF WOHLER'S ALTERNATING STRESS TENSION MACHINE

*A* is the specimen. *B* and *C*, shackles. *C*, beam. *D*, knife edge. *Q*, oscillating connecting rod. *E*, lever with variable stroke. *T*, beam. *H*, spring. *K*, lever controlled by spring *L* and nut *M*.

sibly on the eve of finding the solution of many riddles connected with the behaviour of materials subjected to alternating stress. Let us trace out, in an easy fashion, the advances which have been made already and observe the methods used by the various experimenters.

We may, perhaps, be permitted to digress for a moment to remind the reader that many structures or parts of machines are subjected to stresses which vary in magnitude from a certain value of tension stress to a greater, equal or less value of compression stress. Typical examples are the connecting-rod of a steam engine, the axle of a railway carriage and the diagonal bracing in the center of a bridge. It is of importance that the materials used for such parts of machines and structures should be tested under similar conditions. At present this is seldom done, and it must be confessed that free use is made of the "factor of safety," which is too often the factor of ignorance.

### THE TESTS OF WÖHLER

Exactly forty years ago Wöhler published his valuable researches on alternating stress. His machine is illustrated in Fig. I. The purpose was to apply to the specimen A an alternating tension test. The specimen was held in suitable grips or shackles *B* and *C*. The lower shackle *C* was so made that the height could be adjusted by means of a screwed tail rod. This it was possible to fix at different positions relative to the frame of the machine by the nuts shown in the diagram. The upper shackle *B* was carried on knife edges placed at the end of the beam *B C*, which was also supported on knife edges at *D*. A vertical oscillating connecting rod *Q* gives an oscillating stroke to the lever *E*. This stroke was varied by means of a slot and pin. At the end of a lever *C* there was a link which was attached to the horizontal beam *J*. The other end of *J* was attached to a lever *K* and a stiff spring *L*. The tension on the spring *L* was adjusted by the nut *M*.

When the machine was at work *Q* had an up and down motion, which was transmitted by the lever *E* to a pin working in the slot *F*. This in turn was transmitted through the

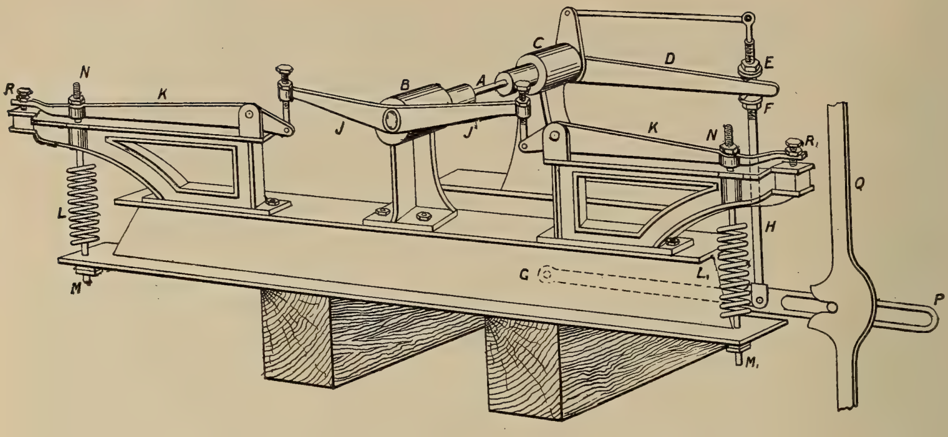


FIG. 2.—WOHLER'S ALTERNATING STRESS MACHINE

*A* is the specimen held in chucks and bearings at *B* and *C*. *D* is a lever with knife edges at end. *H* is a vertical rod attached to lever *P*. Adjustable collars are *E* and *F*. Connecting rod *Q* pivoted at *G* operates *H*, and so twists *A*. Levers *J J*, *K K*, etc., transmit reaction of torque to springs *L L*.

spring *H* to the beam *J*, and so to the specimen *A*. The purpose of the spring *L* and the lever *K* was that the latter would rise when the desired maximum stress was on the specimen *A*.

Wöhler also designed an alternating torsion stress testing machine, which is shown in Fig. 2. The diagram is self-explanatory.

We now come to Wöhler's alternating bending stress machine. There were two types, but Fig. 3 shows that which was the inspiration for other investigators. Two specimens $A$ $A_1$ were used with this machine. They were carefully turned in a lathe to be made quite straight. There were bearings at $E$ $E_1$ and a certain bending pull was placed on the specimens by adjusting springs $F$ $F_1$ by the nuts $G$ $G_1$. The pulley *B* was rotated by means of a belt. This was keyed to the mandril *C*, which ran in bearings $D$ $D_1$. It is fairly obvious that when the specimens $A$ $A_1$ rotated they were subjected to a bending stress which alternated every revolution between a maximum value tension and compression. In short, the usual state of stress on the axles of a railway carriage was reproduced. An elementary diagram of this Wöhler machine is shown in Fig. 4, where the specimen was gripped in a lathe and made to rotate while a weight was suspended at the end.

The results obtained by Wöhler were many and important. They substantiated, for the first time, by direct numerical data, the statement that the range of stress had an effect upon the number of revolutions an axle could run before fracture. With maximum values of 23.9 tons per square inch tension and compression a material (homogeneous iron) was rotated 2,375 times and then fractured. With maximum 16.3 tons per square inch for these stresses 94,311 revolutions were recorded. With maximum values 11.5 tons per square inch 3,930,150 revolutions were made before fracture. The results on Krupp's cast-steel axles were equally striking. With alternating tension on compression tests of 20.1 tons per square inch 55,100 revolutions were made. When the stresses were 14.3 tons the number of revolutions was 45,050,640. It is worth noting that this material which failed at 14.3 tons after forty-five millions of alternating stresses carried 46.4 tons per square

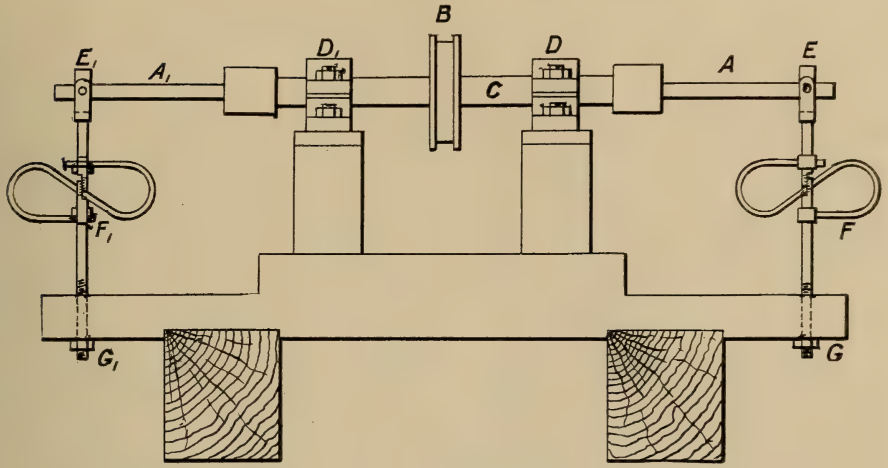


FIG. 3.—WOHLER'S ALTERNATING STRESS BENDING MACHINE

*A A,* the specimens. *D D,* rigid bearings. *B,* pulley. *C,* mandrel. *F F,* springs. *G G,* nuts to regulate pull-on springs and specimens.

inch during the ordinary tension test.

### PROFESSOR ARNOLD'S MACHINE

The well-known metallurgist who holds the chair of that science in the University of Sheffield conceived the idea of making the Wöhler type of alternating stress tests more possible for commercial work by reducing the time taken. He therefore devised a machine (shown diagrammatically in Fig. 5) which stressed the material just beyond the elastic limit. The evidence which has been supplied by the numerous tests made by Professor Arnold shows that his method is more practical and more useful than Wöhler's for commercial work. It is, however, of no value in the rather fascinating search after the causes of elastic breakdown of steels.

In this same catalogue of bending stress machines may be placed that devised by Captain Sankey. This is shown in Fig. 6. The principle upon which the machine works is based upon an exact measurement of the force which bends the test piece backwards and forwards until it is broken, and the number of bends. The ingenuity of the machine consists in the automatic record of these quantities. This machine is now in use in several laboratories and is possibly the most convenient type for commercial work. In fact, some of its admirers go so far as to say that it gives such satisfactory results that the ordinary static tensile tests may be altogether dispensed with. A noticeable feature of the machine is its illustration of what we may call (for want of a better word) the leatheriness of the material.

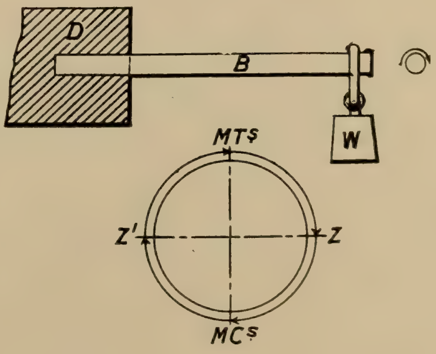


FIG. 4.—A CRUDE WOHLER BENDING MACHINE

The circular diagram shows the variation in stress during one revolution. It goes from maximum tension stress, *MTs*, to zero, *Z*; then to maximum compression stress *MSs* to zero again at *Z'*.

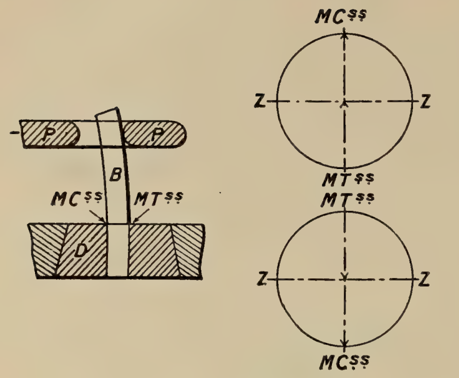


FIG. 5.—PROFESSOR ARNOLD'S ALTERNATING STRESS BENDING MACHINE

*P P* is a reciprocating rod. *B* is the specimen. *D* grips for *B*. *MCss* and *MTss* show where are values for maximum compression and tension stresses.

Incidentally, the writer may mention that he has long held the opinion that the ordinary tensile testing machine is too cumbersome and expensive for the work which it is called upon to perform. He was once struck most favourably (at first) with the idea of rigidly securing the tension specimen at one end to a rotary shaft and at the other end to a weight. The stress would then be applied by centrifugal force. By gradually speeding up the shaft the stress could be increased until the material ruptured—when stops would prevent the weight and the piece of the broken specimen secured to it from flying into space! But a few calculations as to the effect of windage on the power needed was sufficient to make him give up that idea. And yet there sure must be some easier method of applying the forces required to break a specimen in tension.

### PROF. J. H. SMITH'S MACHINE

A very ingenious alternating stress machine which applies tension and compression tests is that which has been developed by Prof. J. H. Smith, of the Belfast Technical School. The load is produced by the centrifugal force of a rapidly-rotating mass. Fig. 7 shows a general scheme of the apparatus. Two masses $W_1$ are fixed at the ends of revolving arms which are pivoted at *A* and *B*. When the

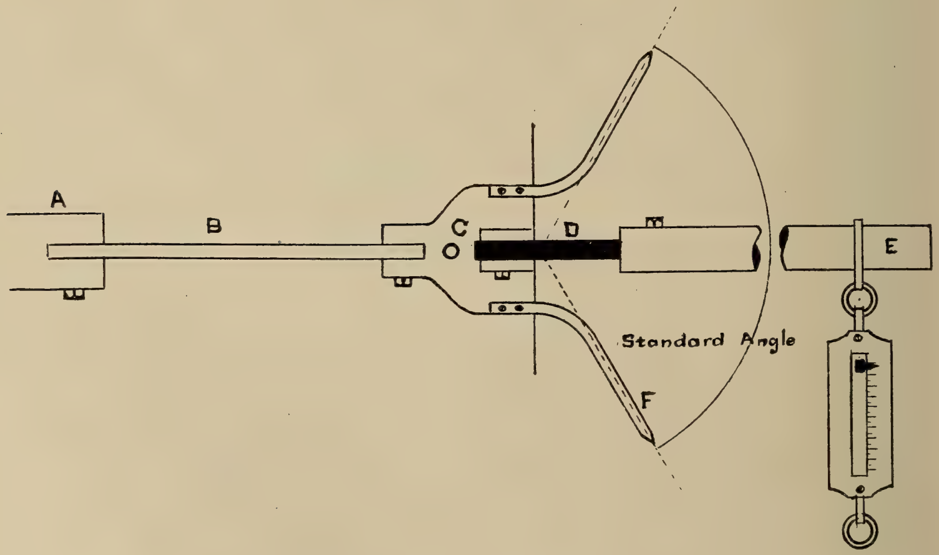


FIG. 6.—CAPTAIN SANKEY'S BENDING MACHINE

*D* is the specimen. *F*, the stop. *E*, the lever to which is attached the springs. *B* is a flat steel spring, secured rigidly at *A*, which actuates a recording mechanism.

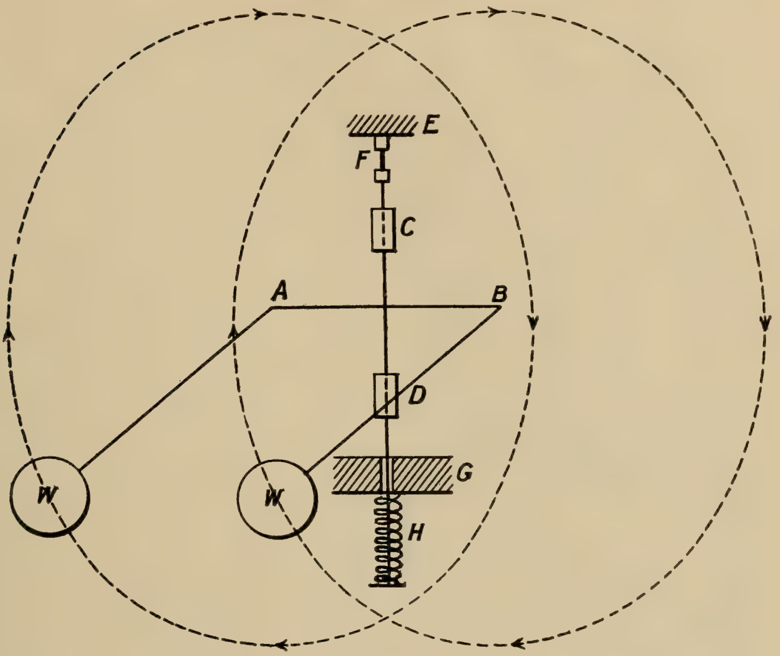


FIG. 7.—DR. J. H. SMITH'S ALTERNATING STRESS TENSION MACHINE

*F* is the specimen. *C D*, guides. *B*, arm. *W*, weight. *E G*, fixed masses. *H*, spring.

weights are at the top of their motion they will pull *A B* upwards with a force

$$F^1 = \frac{2\,W\,V^2}{g\,r}.$$

If now *A B* is rigidly attached to a spindle passing through guides at *C* and *D*, and if the specimen *F* is placed between the end of the spindle and a fixed mass *E*, then the specimen will be compressed with a force $F^1$. When the weights are at the bottom of the revolution—*i. e.*, at 180° with the specimen—the force will be reversed. It is therefore so arranged that a spring *H* is placed at the bottom of the spindle and this is tightened up until there is a force 5 pounds weight. Then the load on the specimen will vary between

$$\frac{2\,W\,V^2}{g\,r} - S \text{ and } \frac{2\,W\,V^2}{g\,r} + S.$$

Fig. 8 shows the idea of the machine as actually carried out in practice. There is no rigid connection at the point *A*, for the arrangement is a small slider working in guides; otherwise the driving shaft would take up part of the forces due to the revolving weights.

It will be noticed that weights are introduced for the purpose of balancing the machine. As a matter of fact, the part shown in Fig. 8 is duplicated, in the actual apparatus, with the object of securing perfect balance. All of the machine is immersed in oil. The specimens tested are quite small, being a quarter of an inch in diameter and half an inch long. An ingenious optical strain recorder and a stress-strain oscillograph are used.

Dr. Stanton, of the National Physical Laboratory, has also devoted great attention to this subject of alternating stress and has devised a machine of the connecting-rod crank type, from which many results have been obtained. He has also designed a most ingenious apparatus in which

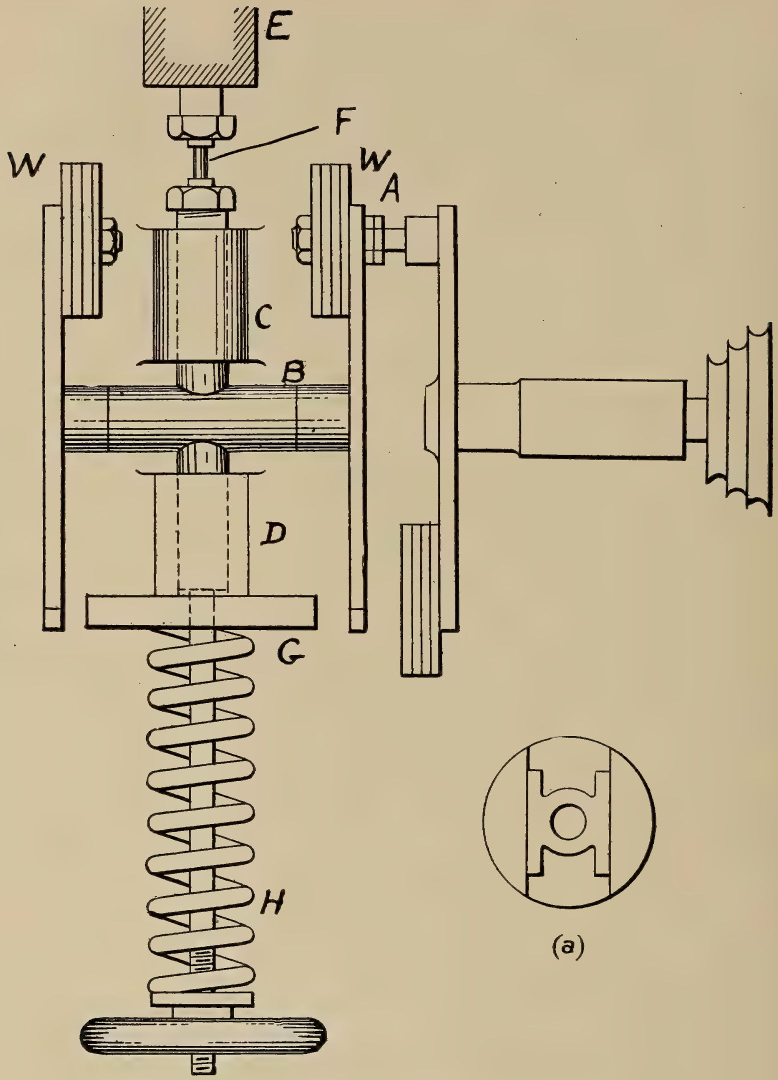


FIG. 8.—DR. J. H. SMITH'S MACHINE

*F* is the specimen. *C D,* guides. *B,* arm. *W,* weights. *E G,* fixed masses. *H,* spring.

the specimen used is a ring in form.

Mr. E. M. Eden has obtained some interesting results with a machine of the rotating beam type (Fig. 9), in which the specimen is subjected to bending and to sheer. Critics rather objected to the Wöhler tests (bending) because of the complications introduced by the shear stress.

The author has devised an alternating torsion testing machine. The principle upon which it works may be illustrated as follows: Imagine a shaft which is made to oscillate and which carries a flywheel. Then the forces necessary to start and to stop this weight may be easily calculated, and so the stress on the shaft may be obtained. The apparatus is still in the course of solution, although some very successful runs have been made in the course of its development.

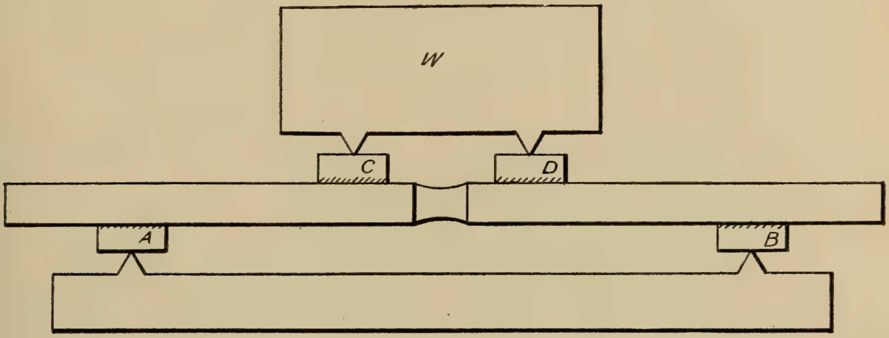


FIG. 9.—MR. EDEN'S MACHINE

*W,* a weight. *C D,* supports. *A B,* bearings. Pure bending, no shear, obtained betwen *A* and *B*.

THE NUMBER OF REVERSALS

So far, then, we may say that many investigators have entered this field of research. The practical man will at once say: "What has been the result?" It has been shown, beyond dispute, that the number of alternations to which a specimen is subjected undoubtedly affects its strength. That in itself is a great advance. There is still more to be learned. The great point at issue now is whether the rate at which the alternations are made has any effect. Dr. Stanton adheres to the opinion that it does not make any difference whether the specimens in these machines—or any materials in machines or structures—are subjected to alternating stress which varies slowly or rapidly. Dr. Smith, Professor Morley and others are opposed to this opinion. The next great step in advance will be the settlement of this debatable point. That can only be achieved by definite evidence supplied by many tests.

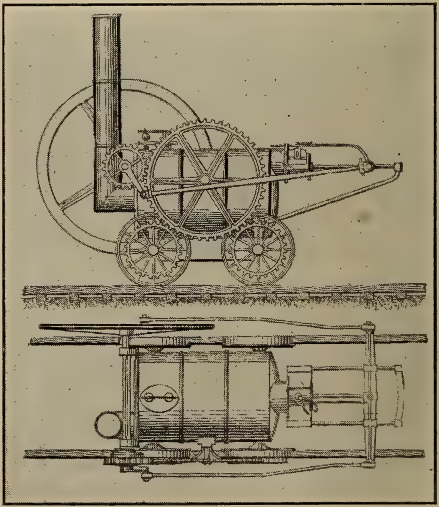
There are many other points which may be cleared up by these and similar tests. Unfortunately the work is expensive. It must cost something in power only to run a machine forty-five million revolutions (as did Wöhler) in order to fracture one specimen. However, progress is not so slow as it would be were there only one investigator in the field. We may hope to have many results during the next decade, and we may even obtain some idea concerning the causes of fracture of brittle and ductile materials under repeated stress.

# THE EVOLUTION OF THE GEARED LOCOMOTIVE

By **William Fletcher**

A LITTLE more than a hundred years ago the first locomotive that ever ran on rails was a spur-driven engine with four coupled driving wheels. It hauled a load of goods and seventy passengers for a distance of 9 miles on a tramway. A flywheel was keyed to the crankshaft, and the engine was made more efficient by the use of a blast pipe in the chimney. This primitive locomotive had a single cylinder, placed in a horizontal position (see Figs. 1 and 2). Twenty years after Trevithick's day, the locomotives built by other hands had vertical cylinders, and were far more complicated as a consequence. Then by degrees the cylinders were restored to the horizontal position, where they are found at the present period. These early engines ran on private lines, or tramways in connection with coal mines. Leaving these old-time locomotives, we come down to recent and more modern times. The locomotives about to be described are gear-driven engines, with horizontal cylinders. They are frequently employed on private railways, but the similarity of the ancient and more recent locomotives ends here. In the present article, two types of gear-driven locomotives for shunting and haulage purposes are dealt with. These geared engines possess some valuable features that are absent in the four or six-wheeled ordinary tank locomotives, or shunting engines. The first type are convertible road locomotives or traction engines, having flanged driving wheels on the axles, in the place of the ordinary driving and leading wheels used for road work. All the leading traction engine makers are prepared to build these engines suitably arranged for use as road locomotives or road rollers, and to supply the necessary details for converting the road engines into geared railway locomotives; in one, two or three of these capacities they are equally efficient. To prepare these engines for running on railways, a few constructive alterations are needed—they must be provided with buffers at each end, brakes on the driving wheels, sand boxes and couplings.

The second type of engine more readily resembles the ordinary locomotive engine. In both cases the entire working parts are mounted on the top of the locomotive form of boiler. The bearings of the driving-axle, crankshaft and countershafts are all carried by the side plates; while the lower working parts, that are familiar to us, resemble the or-



FIGS 1 AND 2.—TREVETHICK'S GEARED LOCOMOTIVE OF 1803

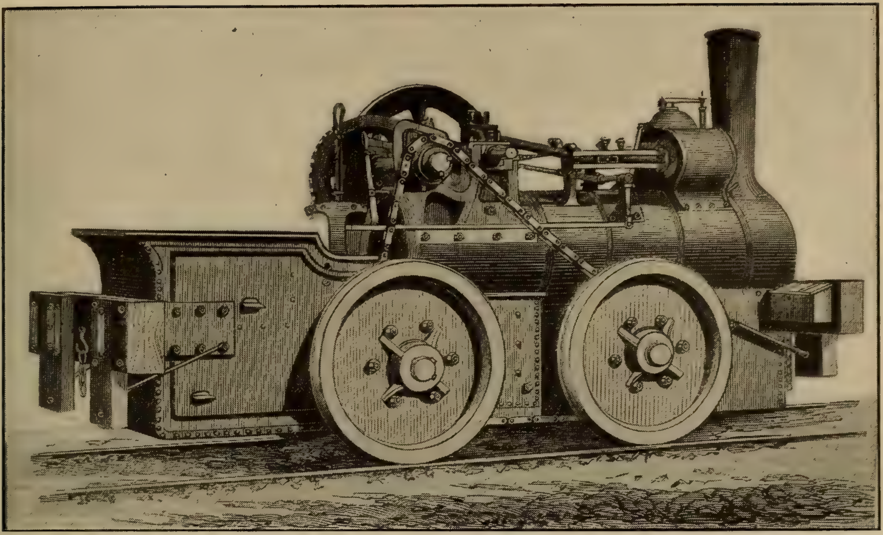
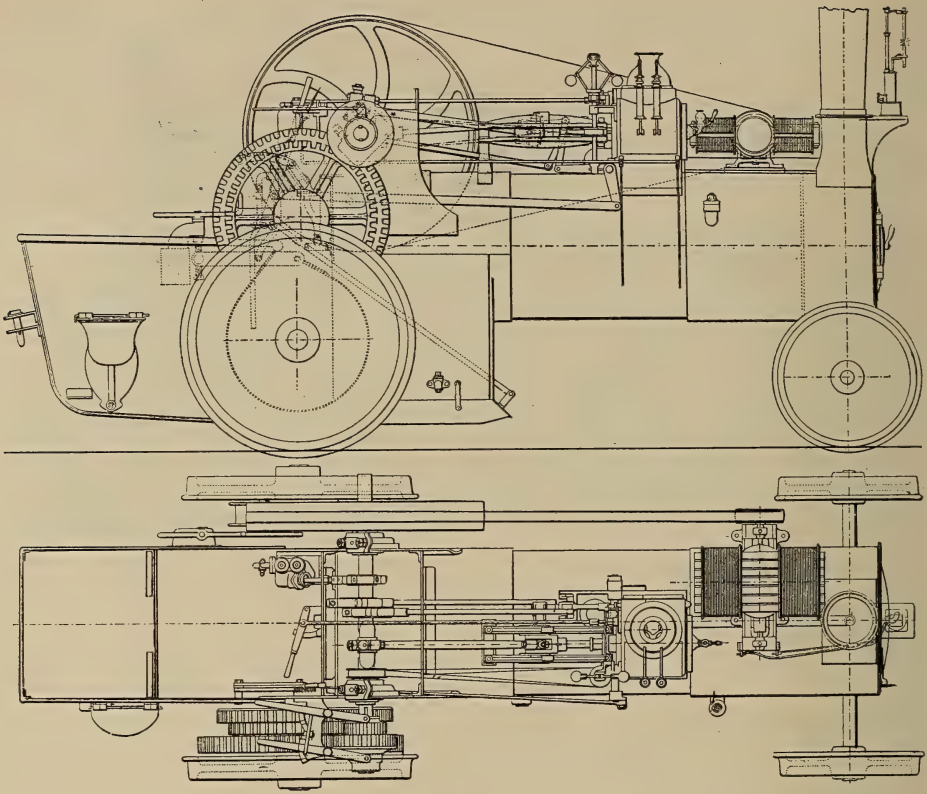


FIG. 3.—EARLY LOCOMOTIVE BY MESSRS. AVELING & PORTER

dinary shunting locomotive. In almost all parts of the United Kingdom tramways are to be found in connection with mines, quarries, dockyards, brick-fields, new railway works, also where canals or reservoirs are under construction.

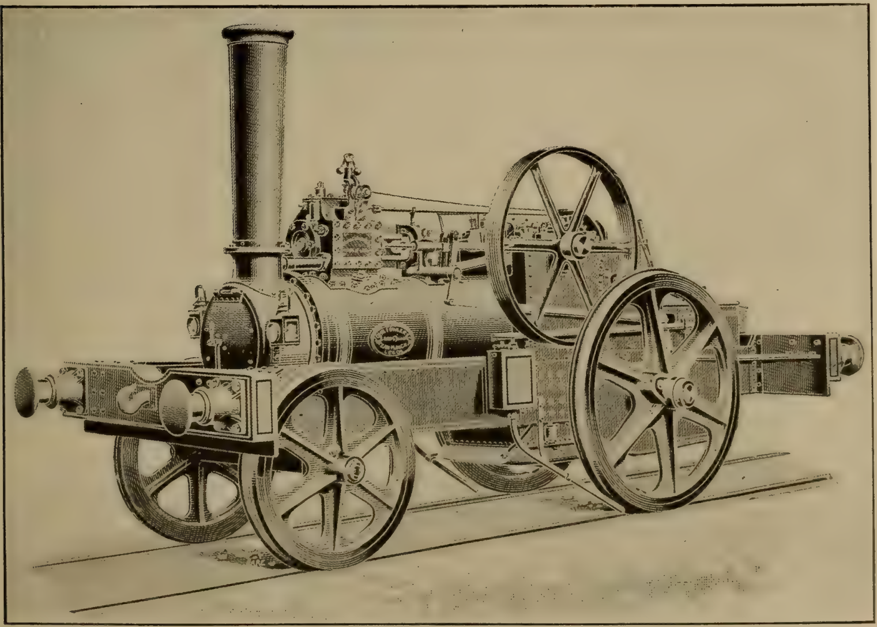
The geared engines are used for hauling trucks up steep inclines, and other rough work where an enormous amount of power is required at low speeds of locomotion. Some of the engines are required to take a gross load of 20 to 25 tons up long inclines of 1 in 20. In one case on the Continent a geared engine had to haul such a load up a steep incline 3 miles in length, the speeds are 2 to 4 miles an hour, respectively. "It will be readily seen that the ordinary contractor's locomotive labours under special disadvantages when taken in relation to either of the above speeds, because it is just at a time when ascending an incline that the full power is required, and then the velocity of the piston does not much exceed 100 feet per minute—a very low rate, and totally incapable of developing to advantage the full power of such an engine. The costly locomotive is reduced to a minimum of power just at the moment when it should be capable of doing its greatest duty." In the geared locomotives to be described, the speed of the piston is more than 300 feet per minute, which is a moderate one when compared with that usually employed in locomotives. What is simply intended by the above remarks is to show that at low speeds, to replace house labour, the geared engine is the best, but beyond that limit of speed the direct-acting locomotive would have the preference. Fig. 3 represents an early form of combined traction engine and tramway locomotive constructed by Messrs. Aveling & Porter over forty years ago. Three of the same design were employed to transmit chalk from quarries in Essex to the docks. On the crankshaft is a pinion gearing into a spur wheel on the second shaft, from which motion is transmitted to the driving wheels (four in number) by an endless pitch chain. The traveling wheels are 4 feet in diameter, with short tires, and coupled by the endless chain. Provision is made for tightening the chain by an apparatus consisting of a slot in the main brackets, by which the bearings of



FIGS 4 AND 5.—TRAVELING ELECTRIC LIGHT FOR RAILWAYS. MESSRS. RANSOMES, SIMS & HEAD, IPSWICH

the second shaft can be raised or lowered. Another feature connected with the employment of such engines is the facility with which it can be applied to the driving of portable or fixed machinery and at the same time retain its means of locomotion. There are two tanks for feed water, one under the tender and the other under the smokebox of the boiler; the tanks hold 350 gallons. All the wheels are coupled; the weight of the engine and tender is available for producing adhesion which is sufficient for the ordinary requirements of such lines. Considering the fact that it can be applied to various purposes on works generally, it is much simpler and less in price than that of the ordinary locomotive. There are other lines, doubtless, where such an engine would be advantageously employed. Figs. 4 and 5 represent a side elevation and plan of a geared locomotive designed by Messrs. Ransomes, Sons & Co. about thirty years ago. This is their usual traction engine altered to suit the different traveling conditions. The engine, it appears, was fitted with a simple electric light plant arranged at the smokebox end of the boiler; dynamo was driven by an endless belt from the flywheel, the light could be produced as the locomotive ran on the rails; or, by throwing out the traveling arrangement, the light could still be maintained when used as a portable engine—that is, stationary on the rails. For a breakdown gang or for facilitating work at night, the engine would serve a useful purpose. No arrangements appear to have been made for shunting purposes; the engine was well adapted for hauling loads on the tramway in the usual way, but some form of rigid coupling would be necessary at the back. The flanged wheels of this engine could be readily removed, when the usual road wheels and fore-carriage are arranged in their respective positions for acting as a road locomotive. A powerful screw brake is fitted to the hind axle, two traveling speeds are provided, and the ordinary feed-water tank is arranged beneath the foot-plate of the tender. Messrs. John Fowler & Co.'s modern combined traction and locomotive engine is illustrated by Fig. 6. The working parts on the locomotive type of boiler are identical with those on the modern road locomotive; the usual traction engine gearing is also employed. A pair of side plates are connected to the tender, the boiler firebox and front; at the ends of the side plates, cross-plates are used for carrying the buffers. As fitted, the engine is well adapted for efficient locomotive service on railways or tramways, capable of shunting heavy trucks or hauling loads. When required for use as a road traction engine, the flanged wheels, frame and buffers are readily removed and the traction wheels and fore-carriage substituted for ordinary road work. The engine illustrated is also readily convertible into a steam road-roller. It has been put to a variety of uses in both capacities.

Fig. 7 shows a side view of a present-day geared locomotive made by Messrs. J. & H. McLaren. It can be constructed to suit any gauge; and as the ratio of gearing is about the same as the ordinary traction engine, the hauling power of these small locomotives is enormous in proportion to the size of the cylinders. They cost little for repairs and are used on private lines and sidings, where the traffic is not sufficient to necessitate the use of a regular locomotive. In passing, it may be remarked that the engines as illustrated in Figs. 6 and 7 may be fitted with a jib-crane in front; and worked by suitable gearing from the crankshaft of the engine, it would prove to be a most useful combination, and one that has been freely used on road locomotives. The same engines, it



FIGS 6.—COMBINED TRACTION AND LOCOMOTIVE ENGINE. MESSRS. JOHN FOWLER & CO., LTD., LEEDS

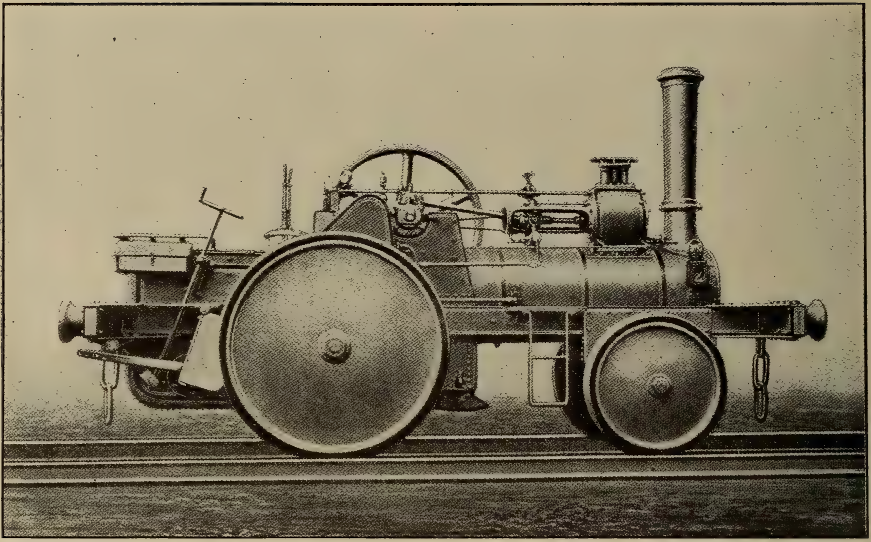


FIG. 7.—GEARED LOCOMOTIVE BY MESSRS. J. & H. MC LAREN

may be stated, can be fitted with a platform at the smokebox end of the boiler for carrying a large dynamo for electric lighting, or searchlight purposes; in this work, however, the locomotive parts must be put out of gear and the engine used as an ordinary portable engine; a belt from the flywheel of the engine drives the dynamo, as shown in Fig. 4. An awning or cab can be fitted to the geared locomotives when required.

This brings us to the second part of the subject. Fig. 8 represents a type of geared locomotive as made by Messrs. Clayton & Shuttleworth. This and others of the same type were built for shunting and quarry purposes some years ago. It will be seen this engine more closely resembles the ordinary locomotive than the three engines previously illustrated. A pitch chain in this instance communicates the power from a pinion

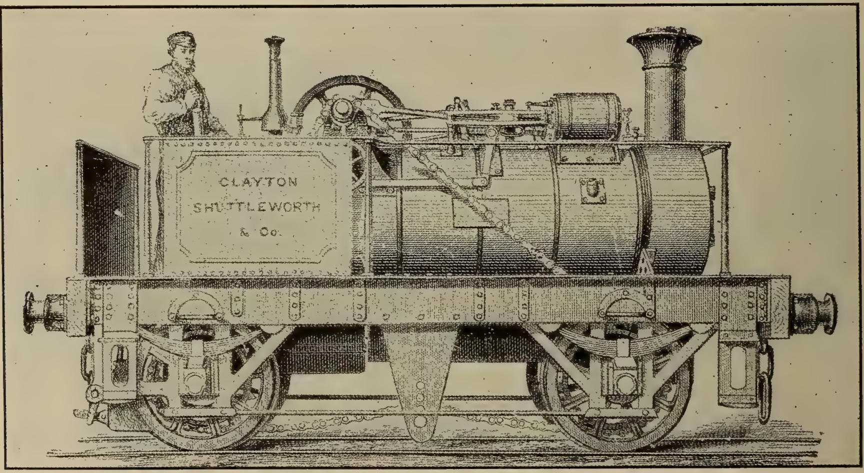
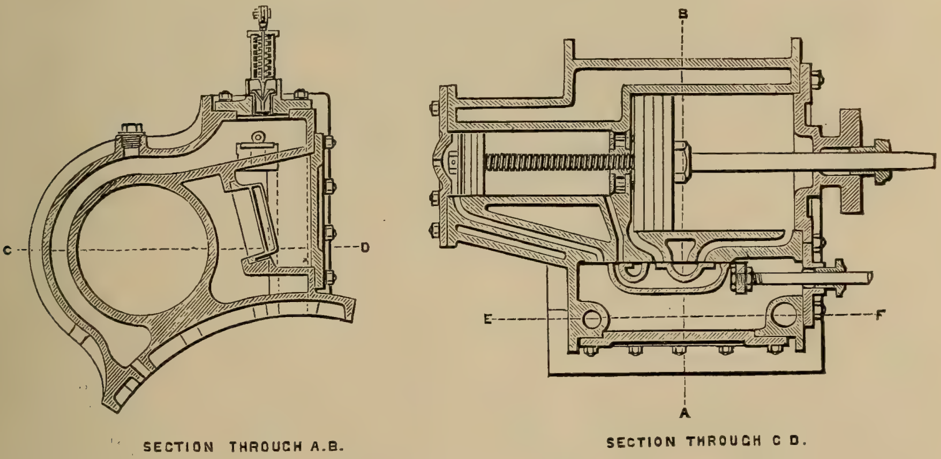


FIG. 8.—SHUNTING ENGINE BY MESSRS. CLAYTON & SHUTTLEWORTH

on the crankshaft to sprocket wheels keyed to the axles; the driving wheels are also keyed to the axles. A jockey pulley fixed on a plate bracket prevents the chain from sagging and touching the ground; the slack of the chain can also be taken up by the pulley. The working parts mounted on the top of the boiler are of the traction engine type. It will be seen from the illustration that the tender, wheels, frame, foot-plate, horn-plates, springs, buffers and other parts resemble the locomotive pattern.



SECTION THROUGH A.B.

SECTION THROUGH C D.

FIGS. 9 AND 10.—ARRANGEMENT OF COMPOUND ENGINE CYLINDERS. MESSRS. AVELING & PORTER, ROCHESTER

A geared locomotive built by Messrs. Ruston Proctor & Co. for use on the Continent may be mentioned. Among the fundamental conditions laid down when the order was given, one was that no chains were to be employed in connecting the driving wheels with the engine. The power is transmitted from the crankshaft to the drivers by means of spur gearing. The two speed pinions and wheels from the crankshaft to the countershaft are placed between the bearings of the two shafts; a pinion on the end of the countershaft drives a wheel mounted on a fixed stud, the wheel on the stud communicates the motion to a spur ring on the driving wheels, the four drivers are coupled. Two feed-water tanks are hung beneath the boiler barrel, one between the axles and the other in front of the fore-axle, extending to the buffer plate. In working trim the engine weighs 12 tons. A large flywheel is fitted for driving machinery when required. It is stated that the total cost of this geared engine is about one-half that of an ordinary contractor's locomotive. The engines so far described are all of the single-cylinder type, but in 1881 Messrs. Aveling & Porter exhibited a tramway locomotive fitted with a tandem compound cylinder, as shown by Figs. 9 and 10. Two spiral springs supported the engine at the back, and one plate transverse spring at the front end, giving a three-point method of support. An H-frame at the back of the firebox was provided for carrying the crankshaft and the driving axle. The frame on each side was in one casting, and moved up and down between angle-irons riveted to the sides of the firebox, so that the engine could rise and fall, owing to the action of the springs, without affecting the distance between the driving axle and the crankshaft, thereby keeping in mesh the gearing between the two shafts. The tandem cylinder as illustrated was Kingdon's patent; the sections require little description.

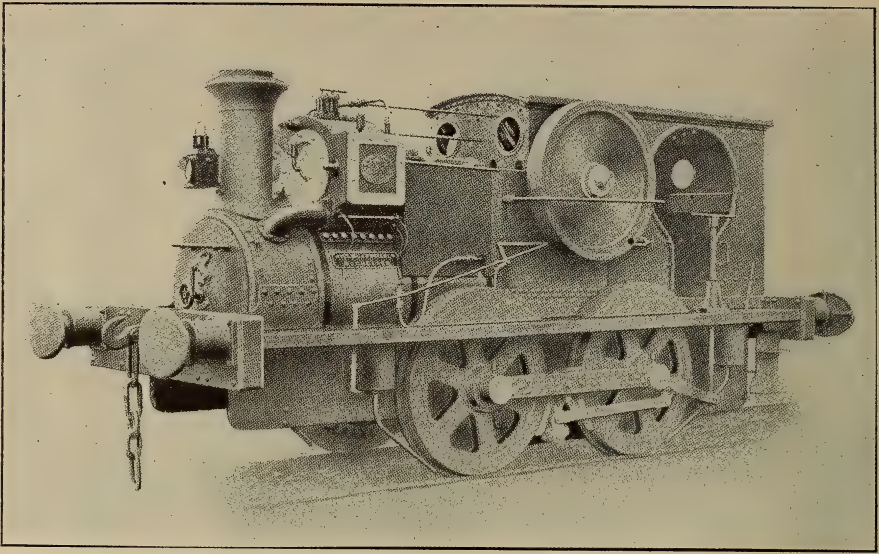


FIG. 11.—AVELING & PORTER'S COMPOUND TRAMWAY LOCOMOTIVE

No packing is used between the cylinders, the piston rod has a series of grooves turned in it, as shown, and by being made a good fit the leakage, it is said, is quite inappreciable in a quick-running engine. One slide valve supplies steam to both the cylinders, to the high-pressure cylinder direct from the boiler, and then conducts the high-pressure exhaust to the low-pressure cylinder, and allows the exhaust from the large cylinder to pass up the chimney in the usual manner. The cylinders are properly jacketed and drained, and are referred to as good examples in the work "The Steam Jacket Practically Considered," 1895. Some of the particulars of this interesting engine are quoted from "The Engineer"; the writer remembers to have seen the engine in 1881.

The tramway locomotive just dealt with was fitted with a tandem-compound cylinder; the next very neat engine by Messrs. Aveling & Porter is on the side-by-side compound cylinder system. This engine more nearly represents the four-coupled tramway ordinary locomotive than any that have so far been described. Fig. 11 shows this clearly. It will be noticed that the slide-valve chests are placed on the outside of the cylinders, admitting the use of larger slide valves and steam ports, giving much easier access for the steam, and very considerably increasing the power of the engine. The compound engine very soon pays for its additional first cost by the economy of fuel and water consumed. There is more duty obtained from the steam in a compound engine than in a single-cylinder engine, for the expenditure of fuel. The side plates of the outer firebox are in these engines extended upwards and backwards, so as to provide brackets, which carry the bearings of the crankshaft, countershaft and main axle in one plate.

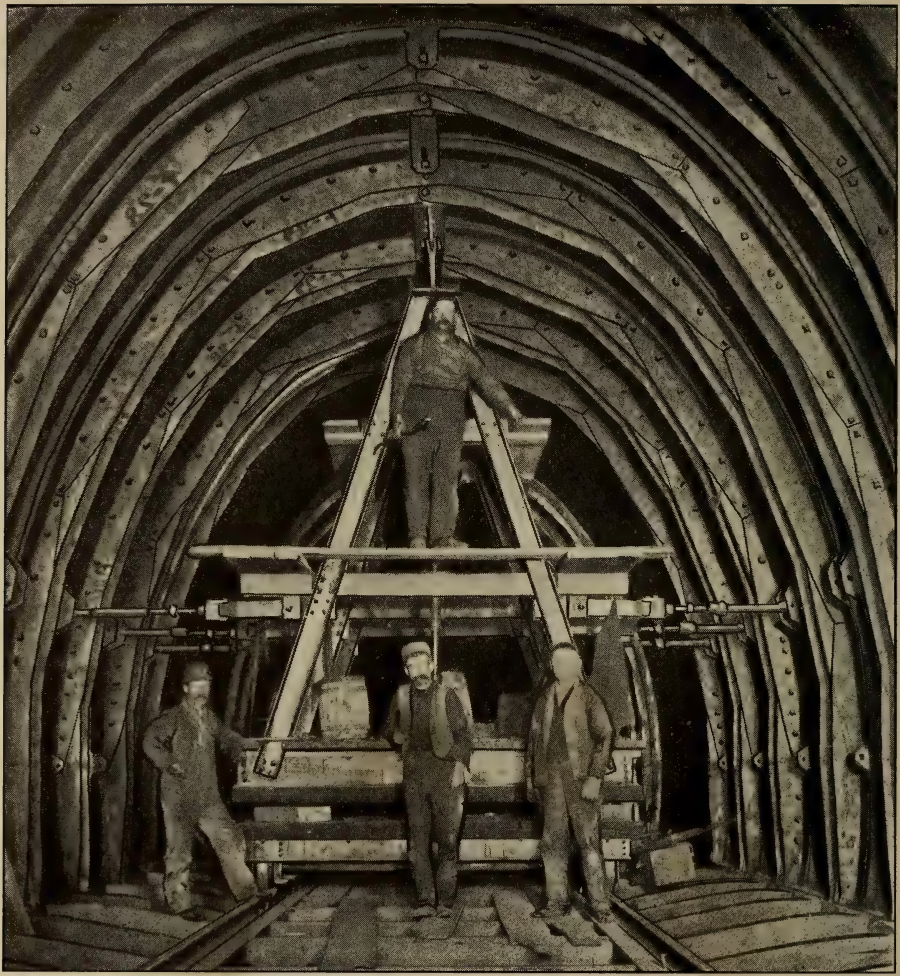
A double-throw crankshaft of best steel cut from the single ingot is used. The wheels are fitted with steel tires, and are under the control of a powerful brake, acting on all the four driving wheels. A flywheel for driving fixed machinery is fitted for enabling the locomotive to be used as a powerful semi-fixed engine. The engine is provided with a neat cab. It is very interesting to compare this modern engine with Messrs. Aveling & Porter's engine, Fig. 3, to see the wonderful evolution carried out, step by step, in a few years.

# THE WATER SUPPLY OF A GREAT CITY

## III.—EQUIPMENT AND METHODS OF WORK

By **J. F. Springer**

THERE is a great deal of concrete construction on the aqueduct. Especially is this the case where the conduit traverses the country on the hydraulic gradient. There is no upward thrust, except that exerted by the water in the immediate vicinity, and so the entire envelope may here be of concrete. This material has very great compressive resistance, but only slight tensile strength. Without suitable reinforcement, either from imbedded metal or from external support, concrete is unsuitable for a pressure conduit. Along the grade, however, where the section is in the form of a horseshoe, the great strength of the bursting pressure is exerted downward and to right and left. This is resisted by the underlying material and the embankment to either side. There may be a small residual pressure outward and upward which the concrete itself will have to take. Apart from its tensile resistance, its own weight and that of the overlying filling give assistance. It remains, then, only to construct the aqueduct to the proper shape inside and out and of the proper materials. If one gives a little thought to the problem of conduit construction, he will see that there is a rather serious question involved. The crown, or upper part, has to be supported and kept to shape from within. Of course, the first thing to do is to pour the invert. By the use of a suitable framework and sheathing of wood a proper mould can then be constructed. But a little consideration will show that the assembling of all this in exact position and subsequent disassembling would be quite expensive. What is needed is a rapid method of building up and taking down. This problem has been solved on this grade work in the open by the use of Blaw centres (Blaw Collapsible Steel Centering Company, Westinghouse building, Pittsburg, Pa.). In the first place, the forms are of steel. They are made in considerable sections, which are readily put together and taken apart. The invert is only slightly rounded. On one contract it consists of 15-foot lengths. The joints are underlaid by key blocks. The alternate sections are first laid down. These are 16 inches wide and 12 inches deep. They penetrate the rock to a depth of 4 inches. A railway track is temporarily arranged to run along the middle of the invert. By its means concrete is readily supplied at the points desired, and the floor constructed. The invert is not constructed continuously, but a set of alternate sections is first laid down. The form consists of two steel plates of 3/16-inch steel. An angle-iron is fixed at top and bottom on each. The two are placed one on each key, and thus constitute the bulkheads. Three staples on each side keep them from spreading. The invert is to be 16 inches thick. Concrete is dumped in place. Three-inch steel shafting is rolled over the top of the steel forms and a smooth surface secured. It will thus be seen that the formation of the invert is a very simple process. The ground and key blocks form the under surface of the mould. The steel forms are the end pieces, and the upper surface is brought to shape by the steel "rolling-pin." When the alternate sections are to be



COLLAPSIBLE STEEL CENTERING FOR CONCRETE ARCH WORK. BLAW COLLAPSIBLE STEEL CENTERING COMPANY, PITTSBURG

poured the steel end pieces are dispensed with, as the ends of the sections already cast are sufficient. The roller is 16 feet in length, and so has a 6-inch allowance at each end. The inside faces of the steel forms are smooth, the angle-irons being placed on the outside. The lower one assists in holding the form erect; the upper one affords a suitable surface of contact for the roller. The staples afford an easy method of setting and dismounting. The construction track is carried on small trestles, and is sufficiently elevated to permit the concreting of the invert.

The sides and crown constitute, however, a more difficult piece of work. It is here that the Blaw centres find their service. The sections for the inside shell are each 15 feet in length. Each section consists of three sub-sections, each 5 feet long. A sub-section is jointed parallel with the axis of the aqueduct at three points—at the crown of the arch and at the springing line on each side. The steel sheeting of which it is made is reinforced by channel bars following the outline of the aqueduct section. The reinforcement is strengthened by plates secured to the edges of the channels. Four lines of timbers are arranged on the invert parallel to the axis. The interior pair are rather heavy (10 x 12), and are suitably spaced to carry a railway track. Along the outer edges of the invert the remaining two lines extend. These are small timbers and support the bottom edges of the steel forms. Three lines of transverse struts assist in keeping the longitudinal timbers in place. Corresponding to each 15-foot form is a truck carrying a rotatable platform. This platform supports three A-frames of steel shapes. Each of these corresponds to a 5-foot subsection of the form. There is a vertical rod arranged with each A-frame, which may be raised and lowered by a screw jack at the bottom. At the top there is hinged a T-bar, with horizontal element of the T arranged parallel to the axis of the aqueduct. There are screw jacks which extend outward from the lower parts of the A and act as arms to support the form at about the springing line.

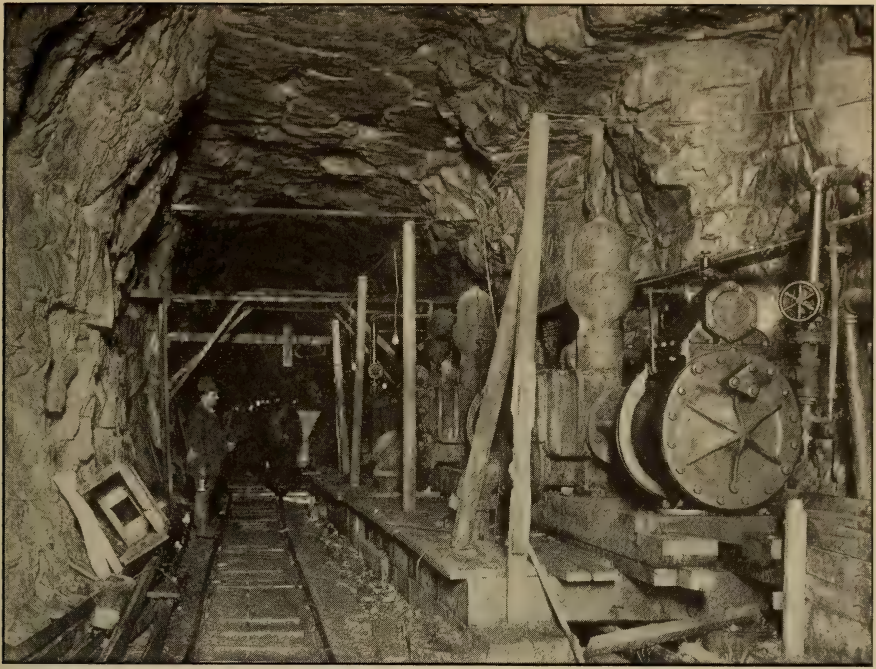
We will suppose a 15-foot section of the internal shell to be mounted on the carriage formed of the A-frames. The vertical jacks are lowered, the horizontal ones drawn in, and the side pieces below the springing line swung inwards. The section is now collapsed. It may be run on the track to another position ahead. Here the jacks will be operated to bring the exterior surface of the form to exact position, and the bottom pieces will be swung outward to correct place—with the proper timbers beneath it. To remove the form after the concrete has hardened sufficiently, the jacks are extended and the supporting timbers taken out, when the jacks may be contracted and the form moved ahead after drawing in the bottom portions. We have here an application of the collapsible idea, which is attracting such attention in culvert and sewer construction. In collapsing the form from the concrete the first movements of the jacks must be quite slow, so as to avoid bringing concrete with it. A 30-foot section requires about six hours for the entire cycle of operations of collapsing, moving forward and setting the forms.

It will readily be understood, upon considering the matter, that while a standard exterior form may be continually in view, the conditions at particular points may be such as to permit, or perhaps require, variations in details. Thus, the thickness

HAYWARD GRAB BUCKET DIGGING SAND FOR MAKING CONCRETE

INGERSOLL-RAND ROCK DRILLS ON TUNNEL WORK

of the invert is standardized at 16 inches. When the aqueduct is empty this thickness is deemed sufficient to withstand the upward thrust of an exterior hydrostatic head 9 feet above the invert. If the head is greater at particular locations, the invert may have to be made stronger. The side walls of the standard form are, of course, thickened at the bottom. The internal height of the aqueduct is 17 feet and the water level is taken as 15.3 feet above the invert floor. At the bottom of the side walls there is an outward thrust of about 900 pounds per square foot. This outward thrust diminishes to nothing at the internal water level. Similarly, on the outside there may be an inward thrust strongest at the bottom



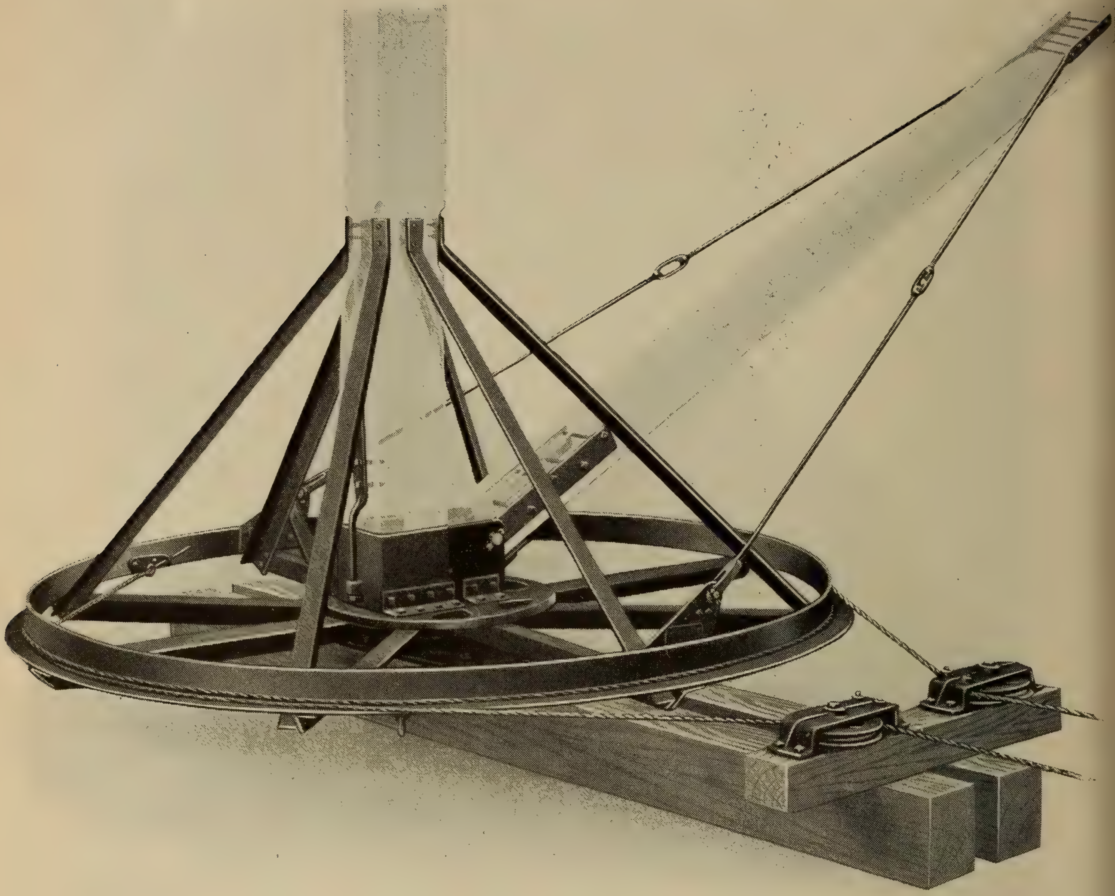
A CAMERON STEAM PUMP IN THE AQUEDUCT TUNNEL

and vanishing at the external water level. These would tend to counteract each other under normal conditions, and would thus enable the side walls to be reduced in thickness. But the design must take into account the simultaneous presence of one and absence of the other. It would seem, however, that a wall competent to take care of the internal stresses when operating alone will withstand all other conditions.

When we consider that at times the entire aqueduct is above the original surface and at times almost buried beneath it, that at times it passes through strong, compact material and at times through soil of a very different character, we are prepared to understand that not only will the external form of the concrete suffer modification, but the disposition of the material banked up against the aqueduct on either side. Where the conduit does not pass through a cut or only through a shallow one the strength of the concrete is reinforced by an embankment. This may widen out greatly on either side, having an external slope of 1 on 1¾. There is thus provided a varying reinforcement, with the strength and weight where needed. In other cases there may be a cut through strong material. Even the concrete on the sides at the base may be much reduced, the material *in situ* affording the necessary resistance. And so it goes—the local conditions serve to modify details.

When the various effects of multitudinous conditions are seen it is not difficult to understand that locating the line of the cut-and-cover portions of the aqueduct has not been so simple a piece of work. Often there were several alternative routes, differing only in minor conditions. Here it was largely a question of the comparative costs.

Just as with a railway, excavation has to be carried on, and sometimes on an extensive scale. Thus, a certain section of cut-and-cover con-



BULL WHEEL DERRICK USED ON THE CATSKILL AQUEDUCT. AMERICAN HOIST & DERRICK CO., ST. PAUL, MINN.

struction in Ulster County, 9 miles back from the west bank of the Hudson River and perhaps 60 miles to the north of New York City, has a total length of about 2½ miles. The excavation here amounts, so it is estimated, to 176,000 cubic yards. This is about 41½ cubic yards per lineal yard of the aqueduct. The great machine for this work is the steam shovel. And the efficiency of this piece of apparatus is conducive to promptness and economy. It can scarcely be said that the Catskill aqueduct could not be built without the steam shovel. Such a remark might, perhaps, be made as to the Panama Canal, where an enormous amount of excavation has to be done under tropical conditions. All the same, the steam shovel is one of the most important tools on the Catskill work. It keeps ahead of the concrete work at a distance of, perhaps, 400 feet. Upon excavating, the next question is the disposition of the spoil. On the contract already referred to it is either carried back or dumped onto the finished arch to be used as filling. On this particular contract there is only about 2 per cent. less refilling than excavating. Consequently, if the concrete construction falls much behind and no further opportunity occurs for using the excavated material on the arch, there seems to be no real loss, but perhaps an advantage gained, in transporting it ahead and dumping it where the shovel will encounter it as it proceeds with its work. There is thus entailed a rehandling of the spoil, and this may seem disadvantageous. Apparently, the only alternative to rehandling is cessation of excavation. And the objection to this lies in the uncertainty of the ground ahead and the speed of the shovel in it. Altogether, it seems to have been deemed wiser to keep the shovel constantly at work and take no chances on delaying the concreting.

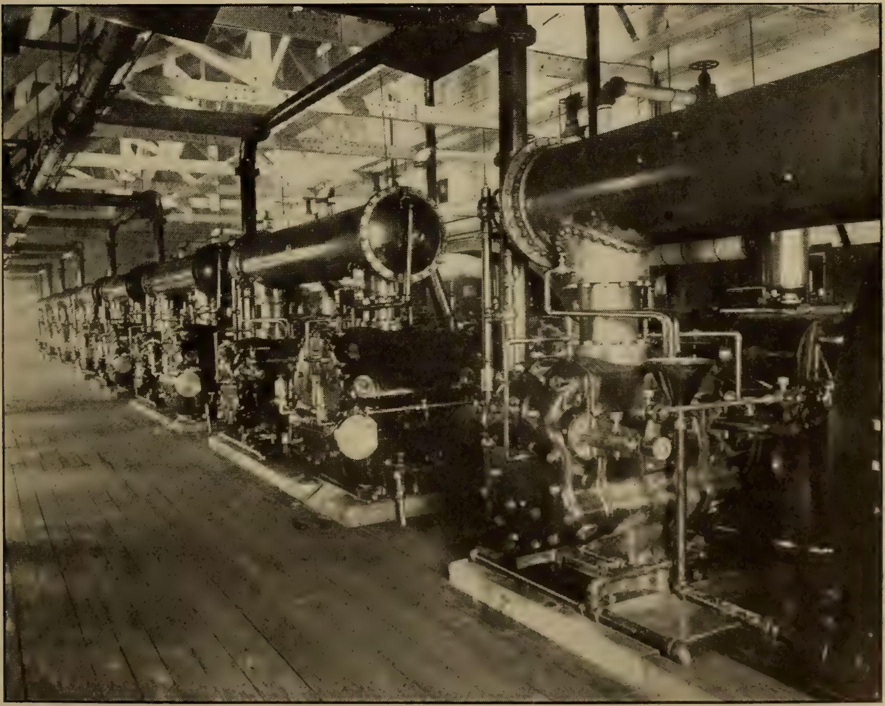
### THE HANDLING APPARATUS

The machines used for handling materials at Ashokan reservoir and along the line of the aqueduct bear familiar names—some of them ancient names. Yet, as we might expect, there are disclosed modern, up-to-date forms and procedures. The derrick is a very old piece of contracting equipment. And, no doubt, there are many cases on the work where the form used is very old indeed. But aqueduct contractors are employing many machines whose power and efficiency place them in another class than that of the ordinary derrick. In the familiar form there is a mast resting on a pivot at the bottom and secured in a more or less upright position by means of guy ropes. Hinged to the foot of the mast is the boom. A hoisting rope passes over a sheave or pulley arranged at its upper end and thence passes through a pulley block and returns to the end of the mast. By operating this line the load may be lifted and lowered. The boom itself may be elevated and depressed by an independent line. It may also be rotated, but this is usually accomplished by a hand line. Such is the ordinary derrick used by the contractor. Its fundamental features are of very high practical value. Very heavy loads are lifted, transported to almost any point within the circle of its action, and there deposited. Loads may be lifted from points far below the surface and placed at points above it, and vice versa. It is thus an appliance of the highest importance, and we may expect to see derricks embodying the principal features used for a long time to come. But the details are not all that is desired. Perhaps the most important improvement is in the power rotative of the boom and load. The American Hoist & Derrick Company (St. Paul, Minn.), which has furnished a multitude of the derricks used on the aqueduct, employs a horizontal wheel attached to the foot of the mast. This is called the *bull wheel*. It has a radial flange at the bottom of its periphery which supports the one or two loops of steel ropes wound about the rim. Both strands of the rope pass off at one side under control of a couple of guide wheels to the slewing drums of the operating drums, rotation in the opposite direction is secured.

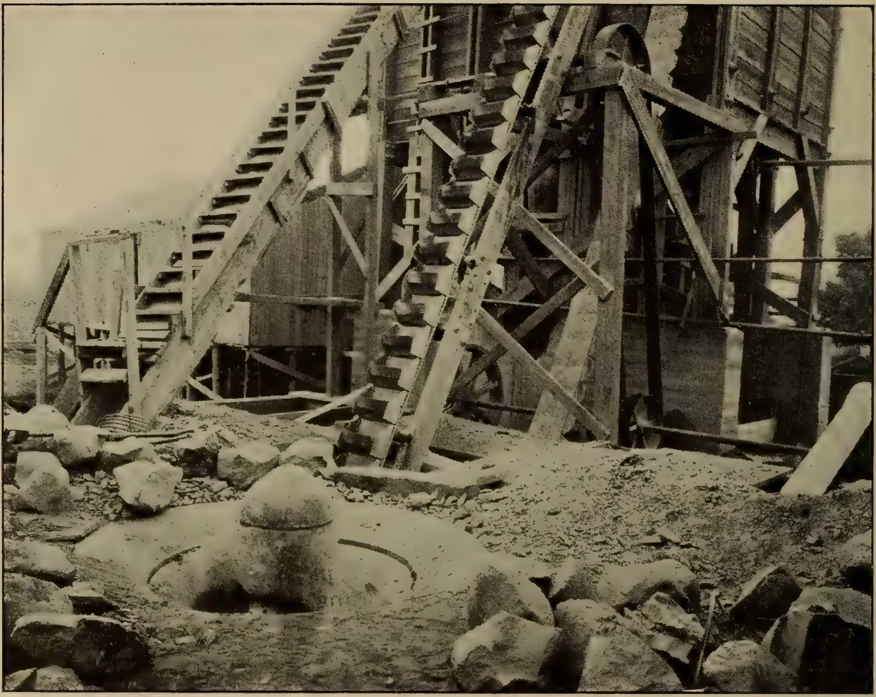
It will readily be understood that with the engine running at a high rate of speed the taking on or release of the load or the machine resistance itself would operate to produce bad results. With the engine furnished by the same concern this matter is cared for by using a friction drive. The load is taken on by degrees, and the swinging of the boom is stopped in the same way. This is an important matter; important elsewhere also in the operation of a derrick, quite apart from any damage to the mechanism. It is well known to those sufficiently familiar with the operation of hoisting machinery and the like that the instantaneous assumption of a heavy load calls for an intensity of power far beyond the horse-power necessary for the carrying of the load when once it is started. A little reflection will show that there will have to be power available to meet the demand. Thus, if the load can be maintained with a horse-power of 12, it may be necessary to have 20 horse-power to

LOCOMOTIVE CRANE AND ORANGE-PEEL BUCKET TAKING SPOIL FROM BANK ON LEFT AND COVERING AQUEDUCT ON RIGHT. THE HAYWARD COMPANY, NEW YORK

start it. The larger power requirement may continue but an instant, but during that instant 20 horsepower must be delivered. A flywheel may enable this to be done without much increasing the constant amount of power available. Another method is to use a friction drive, with which the load comes on and goes off by degrees. This is the method with the slewing mechanism of the derrick engine furnished by this company. There is a special slewing engine made by them which is used on the Catskill work. It performs only the special duty of slewing. It employs but one drum. An objection to this arrangement, which is met in the case of their standard derrick engine by the use of two slewing drums, is that the two lines from the bull wheel are apt to foul each other. When two drums are employed, one for each line, the lines may be kept about 5 feet apart in the region of possible fouling. With this construction the slewing drums are carried on a single axle. It should be noted, too, that the engine always runs in the same direction, the reversal of the slewing motion being accomplished otherwise. The bull wheels are quite large, ranging from 8 to 16 feet in diameter. The slewing action is performed independently of the hoisting mechanism. It may be set in motion and stopped without interrupting the fast-running hoisting or lowering movement. The driving cranks are two in number and arranged on opposite sides of the machine. They are arranged at right angles with each other, so that there is no danger of the occurrence of dead centres. With a mechanism going through so many stops and starts this is, of course, quite important. The hoisting device is driven by a friction clutch, so that the advantages of gradual assumption and release of load are present. On the Catskill work there are, perhaps, fifty hoisting engines and twenty-five derrick engines (including the slewing device with bull wheel). The simpler engine has two drums, which may operate the hoisting and boom lines of a single derrick or the hoisting lines of two derricks. While the power slewing arrangements are features of the most modern derrick, still the simpler device is quite a favourite. The American Hoist & Derrick Company have furnished about 100 such apparatus used on the Catskill undertaking. In the most approved form the boom and hoisting lines are carried to a point near the top of the mast, whence they are deflected downwards to the casting which forms the foot. Here they pass in and out, but the arrangement is such as to keep the two lines separate, even though the boom swings through a complete rotation. Another type of derrick employed on the work is that termed the stiff-leg derrick. With this there are no guy ropes. Instead, two timbers extend from the top of the mast at an oblique angle to meet two other timbers which extend horizontally out from beneath the foot of the mast. The mast itself is set vertical. There is some rigidity obtainable with this type, and the boom remains in any position where it may have been left, but cannot be swung through an entire circle. There are types of stiff-leg derricks capable of operating through an entire circle, but, so far as the writer is informed, none is in use on the aqueduct work. With the bull wheel attachment the stiff-leg derrick is a fine piece of apparatus. The hoisting and boom lines are brought, one directly from the head of the boom, the other down the mast, after having gone over a pulley near its head. By referring to the illustration, details at the lower part of the mast may be seen. There is a pulley arranged within the mast over which the boom line passes to its groove in the sheave lower down. The hoisting line comes in from the



A SERIES OF TEN CORLISS AIR COMPRESSORS ON THE AQUEDUCT WORK. INGERSOLL-RAND CO., NEW YORK



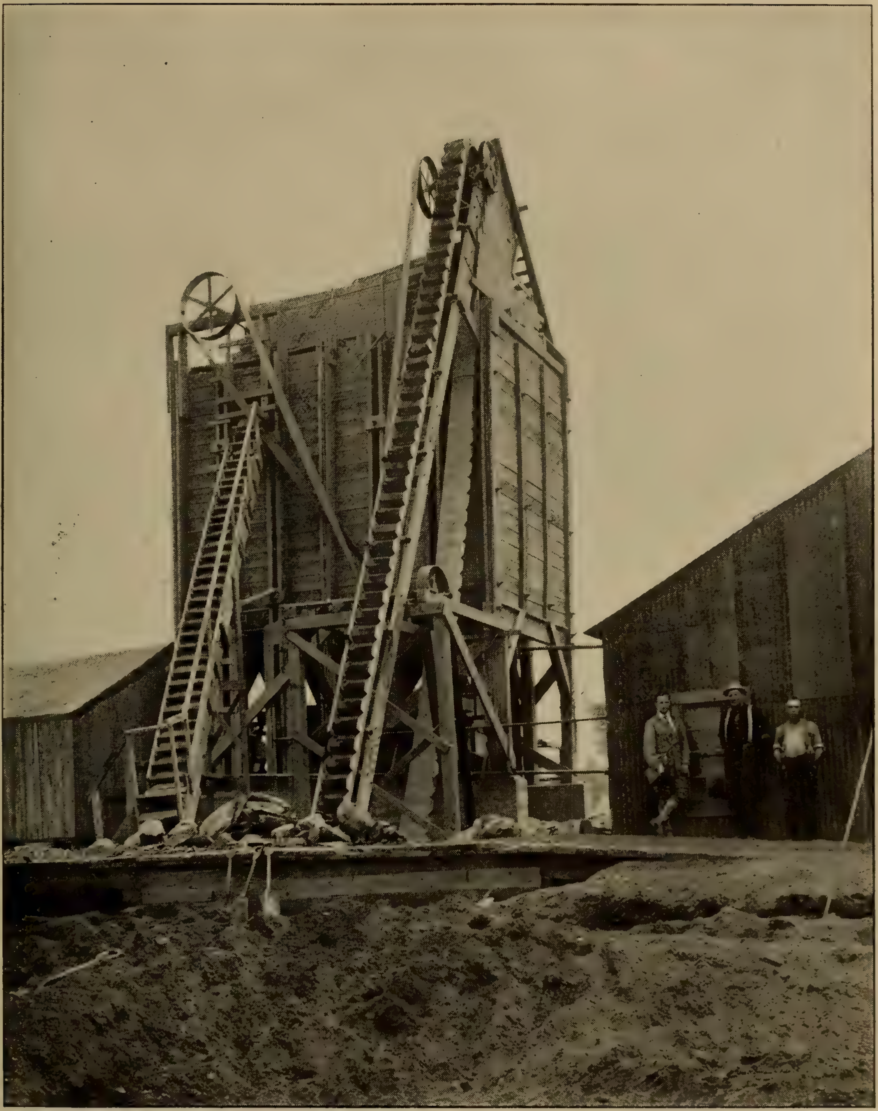
ROCK-CRUSHING PLANT OF THE PITTSBURGH CONTRACTING COMPANY, NEWBURGH, N. Y. POWER & MINING MACHINERY COMPANY

left and passes over the same sheave. Both lines are continued down the axis of the mast through the mast bottom and step to another sheave, whence they pass off to the engine. Derricks are usually stationary, but the portable derrick has found application on the aqueduct. An A-frame is held in position bv a couple of timbers running from its top to suitable points of attachment on the platform of a car or truck. This is arranged a very little forward of the frame and bisects its vertical angle. The operating machinery is carried on the car and acts as a counterbalance of the boom and load. Derricks are now made with booms and masts of latticed steel work, but apparently none is used on the aqueduct.

### THE ROCK CRUSHERS

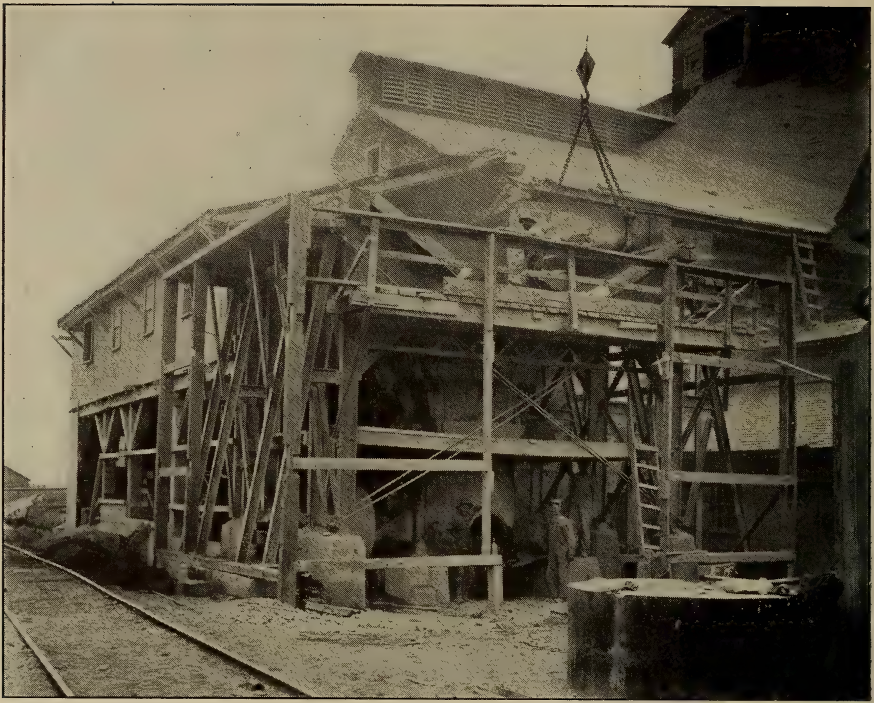
The amount of concrete required for construction work on the aqueduct is, if we include dams and the like, considerably more than 2,000,000 cubic yards. It will be seen at once that the crushing of the necessary rock itself involves a formidable problem.

The chief burden of this great work is apparently carried by the gyratory crusher. There are several forms of this type of apparatus. A typical crusher may be essentially described as follows: The rock is fed into a large, conical hopper, which merges into the body of the apparatus. This is also conical in form, the inclination being, however, quite steep. It is here that the actual crushing is accomplished. A spider having two or perhaps three arms resting on the inner face of the hopper furnishes a support over the center of the crushing compartment. A large shaft is suspended vertically from this support. On this shaft in the region of the crushing chamber is arranged a conical crushing head. Its conical surface tapers upwards and forms, with the downwardly tap-



ELEVATORS AND SCREENS FOR CRUSHED ROCK AT NEWBURGH. POWER & MINING MACHINERY COMPANY

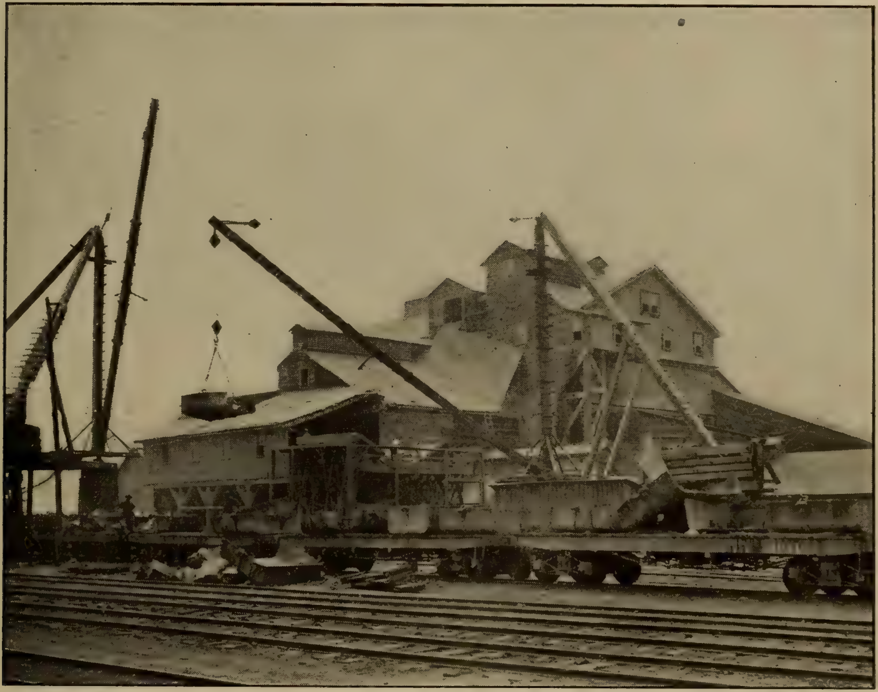
ering wall of the chamber, a kind of annular canyon. Now the shaft hangs a little out of an exact vertical, and in consequence slightly contracts the canyon at one point and slightly expands it on the diametrically opposite side. Indeed, as one goes around in either direction from the point of maximum expansion, the canyon gradually narrows to the point of minimum size. When the apparatus is in operation, the lower part of the shaft is made to swing round a small circle by means of certain eccentric arrangements. The shaft is free to rotate in response to the frictional influences in the crushing compartment. A piece of rock caught, for example, in the most commodious portion of the canyon would find itself between walls, the inner one of which was rolling and



MC ARTHUR BROS. & WINSTON ROCK-CRUSHING PLANT AT BROWN'S STATION, N. Y.

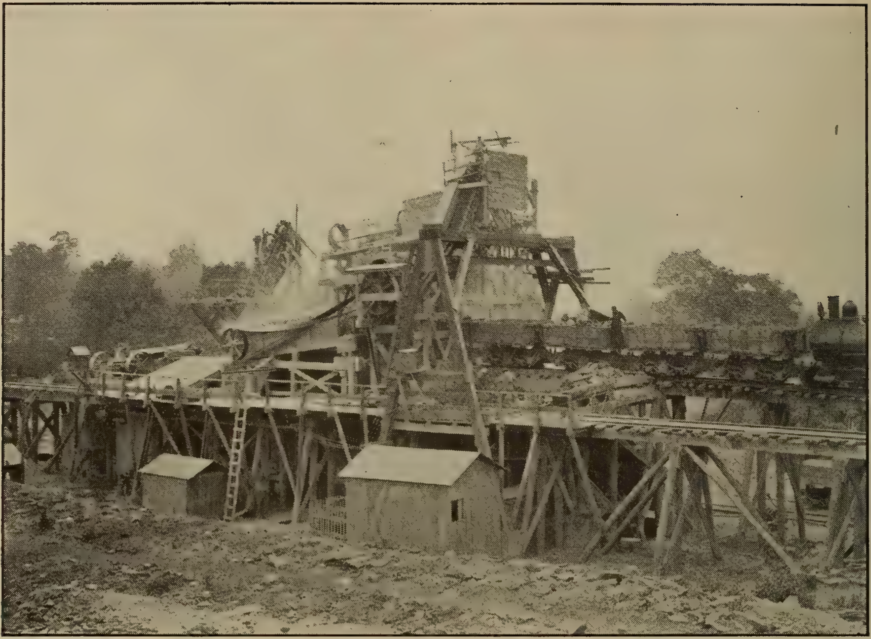
slowly approaching the outer one. Then is here developed an immense crushing effect. In fact, this type of crusher seems capable of dealing with any size of rock that can be delivered to it. On the Catskill undertaking there are thirty gyratory crushers of the style made by the Power & Mining Machinery Company, Cudahy, Wis. It is said that these thirty are crushing over four-fifths of the rock required.

At Brown's Station, N. Y., McArthur Brothers Company and Winston & Co., who have the contract for the main dams at Ashokan Reservoir, have installed a fine plant. The leading machine is a No. 9 McCully crusher, furnished by the Power & Mining Machinery Company. The spider has two arms, so that there are two feed openings. These are each 21 inches wide and 76 inches long. When this machine is set to crush to the 3-inch size it has a rated capacity of 160 short tons per hour. If required to reduce the rock no further than to the 6-inch size the capacity is somewhat more than doubled. This machine weighs upwards of 80 short tons. There are two subsidiary machines—McCully crushers No. 6—whose office is to reduce the rock to still smaller sizes. The quarry which supplies this plant is one mile distant. The transportation of its product is accomplished by means of skips which are loaded onto flat cars. An ordinary car will accommodate four skips. A string of these cars with their load of rock will be run onto a switch conveniently near the big crusher. By means of a derrick the skips are lifted and swung to a point over the hopper. Here an auxiliary arrangement of inclined planes has been provided to assist delivery of the rock to the crusher. A typical skip may be seen on the ground between tracks. A closer view of the arrangements in the vicinity of the crusher is given above. An idea of the size of the machine may be gotten by comparing it with the men standing on the ground at its base. The rock is crushed to 3 inches or less. The whole of the product is elevated and delivered to an inclined rotating screen of the cylindrical type. The perforations of this screen are such as to sift out all rock not larger than 2¼ inches. The diameter of the screen is 20 inches and the length 5 feet. The material from 2¼ inches down is discharged onto an elevator and thence delivered to a pair of screens of equal dimensions with the first. Each of these screens has 1-inch perforations for the first half of its length and 2½-inch perforations for the second half. A dust jacket, provided with ⅜-inch holes, receives material passing through the 1-inch holes of the screen. The siftings of the dust jacket are rated as sand, suitable for mixing with natural sand, the whole to be used in concrete. The first screen of all will deliver from its discharge end material from 2¼ inches up. This is sent to the two No. 6 crushers, where it is re-crushed and delivered to an elevator carrying it to this screen again. The plant has a rated capacity of 1,500 tons of crushed rock per working day of eight hours. Its business is to supply the rock for half a million cubic yards of concrete.



MC CULLY GYRATORY ROCK CRUSHER PLANT OF MACARTHUR BROS. & WINSTON, AT BROWN'S STATION. EQUIPPED BY POWER & MINING MACHINERY CO., CUDAHY, WIS.

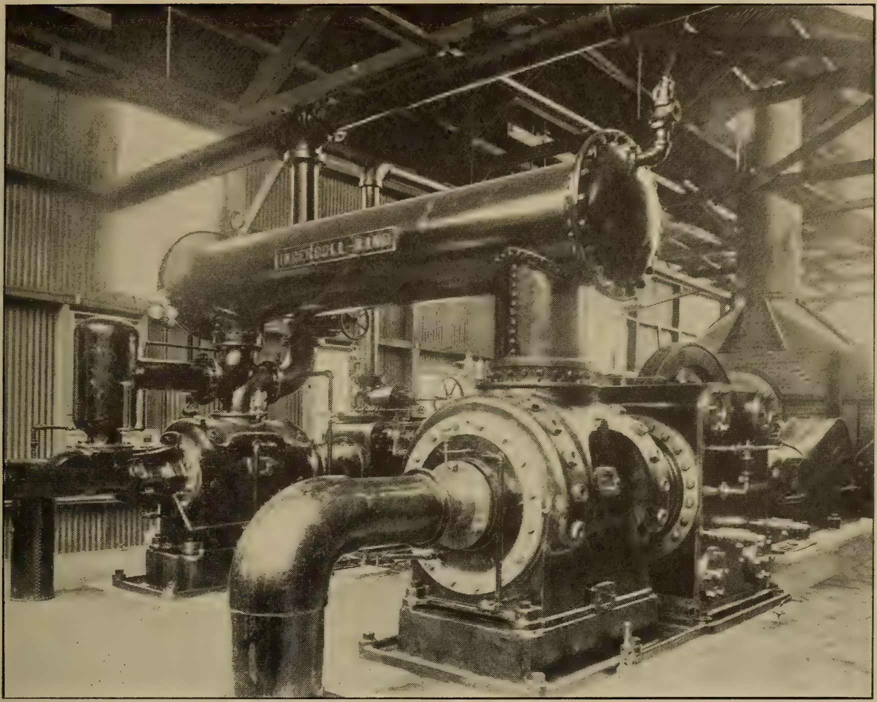
Another plant, a little further south, is operated by H. S. Kerbaugh, Inc. This is at High Falls, N. Y. The installation is somewhat similar to the one just described. The crushers are, however, somewhat smaller and the output per day is about 1,000 tons. The main crusher, a No. 8 McCully machine, is located between two lines of railway trestles. The rock from the small cars is delivered to the inclined feeding platform of the crusher. A crane assists in the performance of this work. The



ROCK CRUSHER OF H. S. KERBAUGH, HIGH FALLS, N. Y. MC CULLY GYRATORY CRUSHER, CONVEYOR & CRANE POWER & MINING MACHINERY CO.

A-frames and the I-beam track for the crane may be seen in the figure arranged to command both tracks and the crusher.

Further south yet may be found the rock-crushing plant of the Pittsburgh Contracting Company. This plant is located at Newburgh, N. Y. The material to be crushed is ordinary field rock, for which the feed openings of a No. 5 McCully crusher are of sufficient size. These openings are 10 × 40 inches. As a supplementary crusher a No. 3 machine is employed. The hoppers of both machines are flush with the general surface of the ground. The rock for the larger one is brought by wagon to its mouth, as shown. The product of this machine falls into a box, from which it passes by overflow to the buckets of the elevator. These buckets may be well seen in the figure. This elevator carries the crushed rock to the top of the plant (see page 447), when it is delivered to a rotating cylindrical screen. The upper half or section of this screen has 1-inch perforations, while the lower section has 2½-inch holes. Altogether the screen is 20 feet long. A dust jacket having perforations of ⅜ inch receives the material sifting through the upper section of the screen. The effect of this whole arrangement is that all material too large for the 2½-inch holes is discharged for the purpose of being recrushed by the smaller gyratory crusher, the cap of whose spider may perhaps be discerned by the reader on the extreme left on page 446. That material which passes through the 2½-inch holes is preserved for use. But none of this material thus received is larger than the 1-inch size. The dust screen receives the material more than 1 inch and sifts out that which is less than ⅜ inch. The material lying between ⅜ and 1 inch passes to mingle with that lying between 1 and 2½ inches. The material less than ⅜ inch in size is rated as sand. The product of the smaller gyratory crusher is carried by elevator to a pair of crushing rolls set to



AIR COMPRESSORS IN PLANT OF MASON & HANGER, CORNWALL, N. Y. INGERSOLL-RAND CO., NEW YORK

reduce the material received to ¼-inch size and less. This "sand" finds its way by gravity to the foot of the elevator serving the large gyratory crusher. Ultimately this material will find its way through the 1-inch holes of the screen and also those of the dust jacket. The pair of crushing rolls are fitted with chrome steel plates 3 inches thick. The surfaces are not corrugated, but are perfectly smooth. Suitable springs are provided to exert a pretty definite pressure per inch width of the roll face. This is sufficient to reduce the rock. If a piece of steel should pass in between the rolls, the spring will permit them to open up for the passage. While this plant is of moderate size, its arrangements appear to be excellent. Its rated capacity is 300 cubic yards of material per eight-hour day. It has been duplicated more than once on the aqueduct.

In some rock-crushing plants the stone and sand bins are so situated that it is possible to run these materials by gravity into the measuring hoppers of the concrete mixers.

### STEEL PIPE

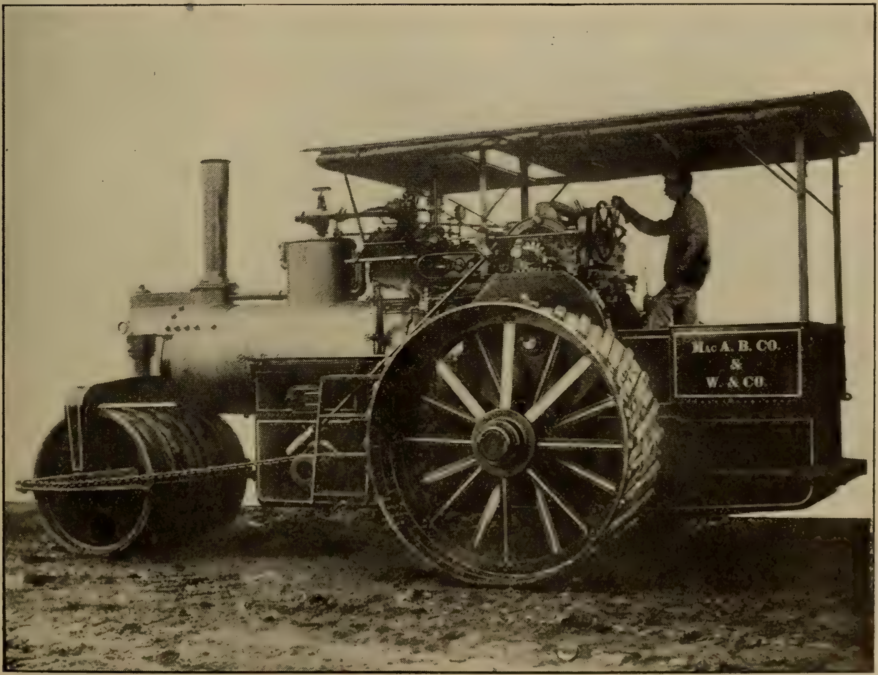
In a former article of this article reference has been made to the steel-pipe construction adopted for the crossing of certain vallevs of moderate width. More than one diameter of pipe is being used, according to the number of tubes used to effect the crossing. The East Jersey Company, Paterson, N. J., are furnishing about 6 miles of pipe of 9.5, 9.75 and 11.25 feet diameter. The thicknesses of the steel plate range from 0.438 to 0.75 inch. The joints are made by riveting. All circular joints are lap-riveted seams. If the plates are 0.438 inch thick the longitudinal seams are lap riveted as well as the rest; if the plates are 0.5 thick, the lap-riveted joint for the longitudinal seams is employed for some of the pipe and the butt-riveted joint for the rest; and if the plates are thicker than 0.5 inch, the butt-riveted joint is exclusively used for longitudinal seams. The pipe having the two smaller diameters and a wall thickness not greater than 0.5 inch was fabricated one sheet to the ring. Then would there be but one longitudinal seam to the ring. Two such rings would be shop riveted to make a 15-foot length. The pipe was then shipped to the field in these lengths. The manner of making the butt joint used on some of the pipe for longitudinal seams was by riveting a longitudinal strip within and without the pipe and covering the seam. The edges of the pipe itself were brought edge to edge. The inner strip was made considerably broader than the outer one. Six rows of rivets, three to each side of the joint, were employed. Two rows of each set of three—that is, four rows altogether—pierced three thicknesses of metal. The exterior rows simply united the pipe and the strip on the inside of the pipe. The rivets in these exterior rows were placed with their centers at double the interval used for the other rows. The two adjoining rows, one of which is to one side of the joint, the other to the other side, have their rivets exactly opposite each other. The positions of the remaining rivets penetrating three plates were staggered with respect to these.

STEEL PLATE RIVETED PIPE, 11.25 FEET DIAMETER, USED ON SECTION EAST OF THE HUDSON RIVER, WESTCHESTER COUNTY, EAST JERSEY PIPE CO., PATERSON, N. J.

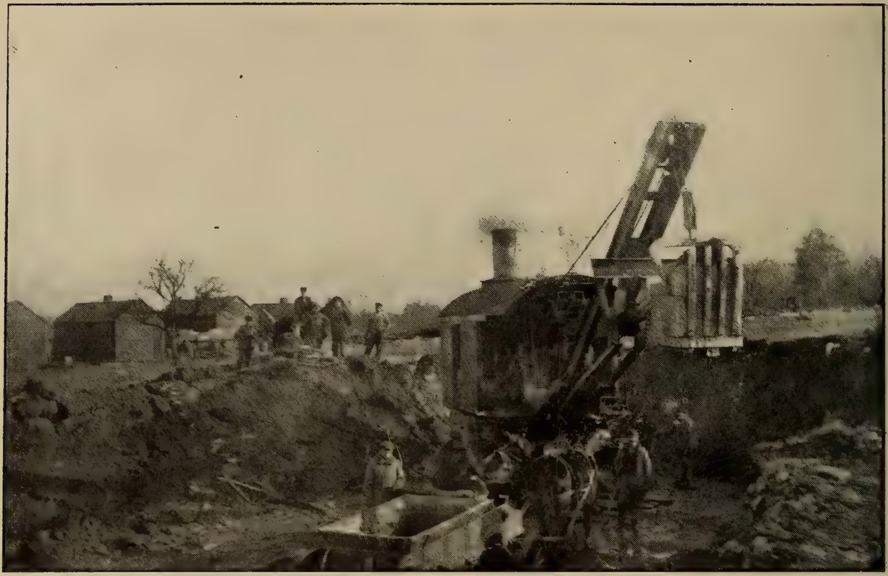
At the crossing of the Peekskill valley, a total of about 6,700 feet of 9.5-foot pipe is required. Here all thicknesses of plate are used. Only a short length of 0.75-inch plate is used. Apparently this 139 feet is located at the very lowest point. Over 1,000 feet, however, of pipe having a 0.688-wall is employed. No other crossing of the fourteen seems to have required any of the 0.75-inch plate.

### ROLLING APPARATUS

The road roller has long been a familiar sight in England and America. Essentially it is a locomotive a pair of whose wheels has been replaced by a cylinder. This cylinder is the roller. The movement of the apparatus over a softened surface has the effect of smoothing and consolidating. The weight of the roller itself, combined with that of the part of the machine which it supports, gives the pressure necessary. The apparatus includes a suitable boiler and engine. The latter is suitably connected by gearing or otherwise with the driving wheels. The operator rides. The essential requirements of such a machine are, in part, strong and effective during connection, ease of control of engine both forward and backward, ease of guidance. If the material on which the rolling is to be done is soft it may be necessary to have broad faces on the driving wheels so found as to prevent slippage. At the Ashokan Dam there is to be an earthen embankment on both faces of the core wall requiring to 6,000,000 cubic yards of material. These embankments are to be built up layer by layer. Each layer must be dampened and thoroughly rolled, the films of earth being limited to a maximum thickness of 6 inches. One readily calculates the number of square yards that must be rolled as in excess of 36,000,000. This is about 12 square miles of surface. It will be understood, too, that a steam roller would be liable to sink down into the work when operating. To provide for such a contingency as this it is necessary to employ very powerful machines. It is said, for example, that horse-drawn rollers are unsuitable for this work, probably because of inability to provide sufficient manageable power to operate rollers of the desired weight. The ordinary steam roller is also inadequate because of the severity of the conditions. To meet the demands at the Ashokan Dam the Monarch Road Roller Company (18 Old Slip, New York City) was commissioned by the contractors to construct ten especially powerful machines. The heating surface in the boilers is said to be double the usual practice, and the power of the engines is increased accordingly.



HEAVY ROAD ROLLER USED BY MACARTHUR BROS. & WINSTON ON THE ASHOKAN DAM. MONARCH ROAD ROLLER CO., NEW YORK



AUTOMATIC STEAM SHOVEL USED BY C. P. BOWER CO., BUILT BY THEW AUTOMATIC SHOVEL CO., LORAIN, OHIO

In such difficult work, where the machine may have to operate despite a serious sinking into the soil, the wear and tear on the gearing has been found to be excessive. In the case of these special machines the face of the main driving gear has been made 7 inches wide. The teeth are also quite large. The pinions on the engine shaft, together with the gears with which they co-operate, have faces 4 inches wide. These provisions seem to be quite adequate, to judge from their behaviour in actual service. Cast iron has, in general, been replaced by steel throughout the machine. These steam rollers are, perhaps, the most powerful anywhere in the world. The cost of the battery of ten was about $32,000. In the photographic view one of these machines is to be seen. An idea of the size may be gained by comparing with the man in the cab. Control of all operations is readily received without leaving his station.

### THE STEAM SHOVEL

There is to-day, perhaps, no more important apparatus employed in engineering operations than the modern steam shovel. It is a machine that has been in use in the United States for perhaps a quarter of a century or more. But like pretty much all other machines necessary to some particular and important line of industrial development it has itself undergone a development of its own. The steam shovel of the present day is a marvel of power and efficiency. The performances in Culebra Cut of the Panama Canal have brought this fact into a strong light. Indeed, the story of the Canal would be a markedly different one apart from the steam shovel. It is the dry excavator of the great ditch. Much the same may be said with respect to the Aqueduct. A very great total of excavation is involved—particularly in connection with reservoir construction and the operations along the line where the cut-and-cover procedure is adopted. The steam shovel is adapted to excavation in ordinary earthen strata; it can operate in soft rock and soil mixed into boulder in a direct manner, and it is highly suited to the removal of the soil from blasting. The steam shovel is particularly economical—as compared with hand labour

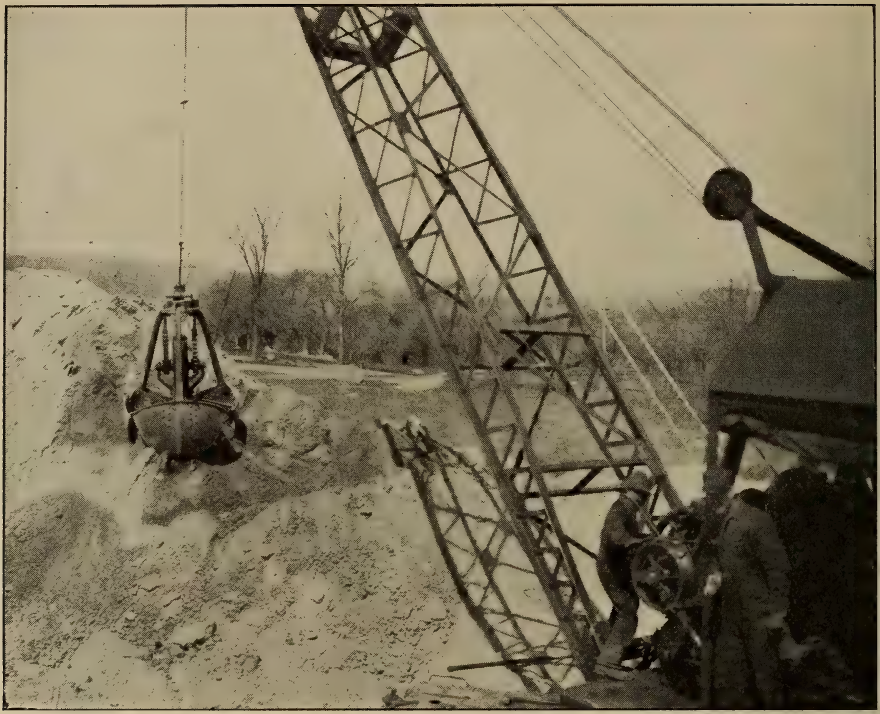
—when employed in connection with blasting. Pieces weighing several tons are readily handled by the larger machines. Because of this ability there is a distinct economy in the expense for labor and explosives in blasting as well as for labor of handling the fragments.

The steam shovel is, first of all, a locomotive. Ordinarily it operates on a track, which has to be laid for it, though only in a temporary fashion. At the working end a stiff boom is arranged. This may be raised or lowered and can, in addition, be swung round to command a considerable range. One great object of this boom is to provide a fulcrum for the lever, at whose lower end the shovel proper is attached. The "handle" of the shovel may have a longitudinal slot, in which case the boom will pass through it. Or the boom have a slot and permit the passage of the handle. In either case the handle swings from a point on the boom perhaps a little forward of amidships. A line attached in the vicinity of the shovel itself passes up over the outer end of the boom, a wheel or pulley being arranged to permit the line being carried back to a hoisting drum in the cab. By operating this line a lever action is produced. In fact, the operation of the mechanical shovel is much the same as with the hand instrument. Thus we may regard the position of the hand further from the blade as that of a fulcrum, and the position of the hand near the blade as that of the point of application of power. The two are then quite the same.

### THE GRAB BUCKET

A most important piece of excavating and handling apparatus is the grab bucket. Just as the steam shovel has invaded the field of the dredge, so has this device invaded the fields of both shovel and dredge. The grab bucket of to-day has ability, not merely to secure and transport a load from a pile of loose material, but to perform an actual digging operation. It cannot do the heavy dig-

ARC VALVE TAPPET DRILLS MOUNTED ON DOUBLE-SCREW COLUMNS. INGERSOLL-RAND CO., NEW YORK

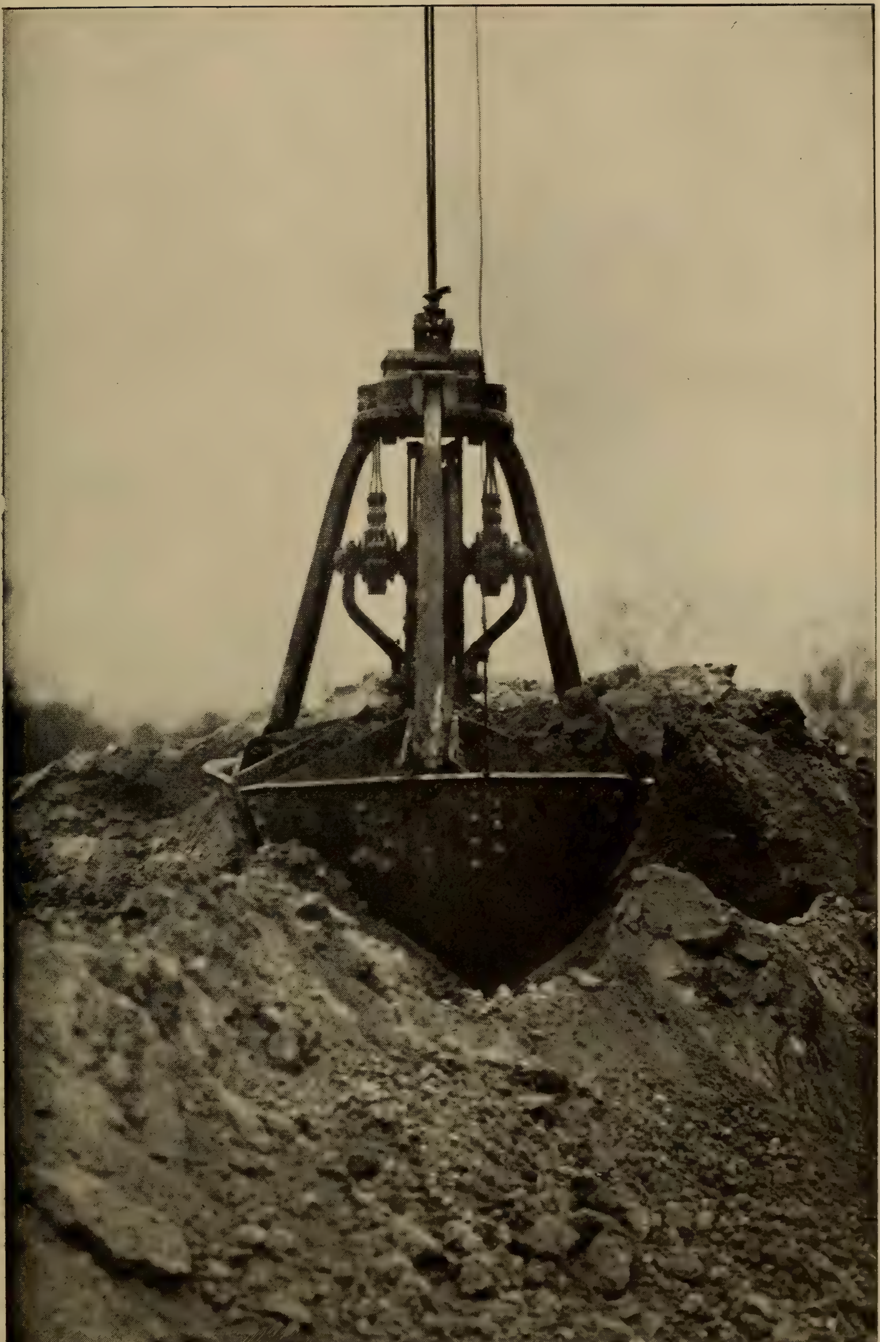


HAYWARD ORANGE-PEEL BUCKET DIGGING INTO SPOIL PILE

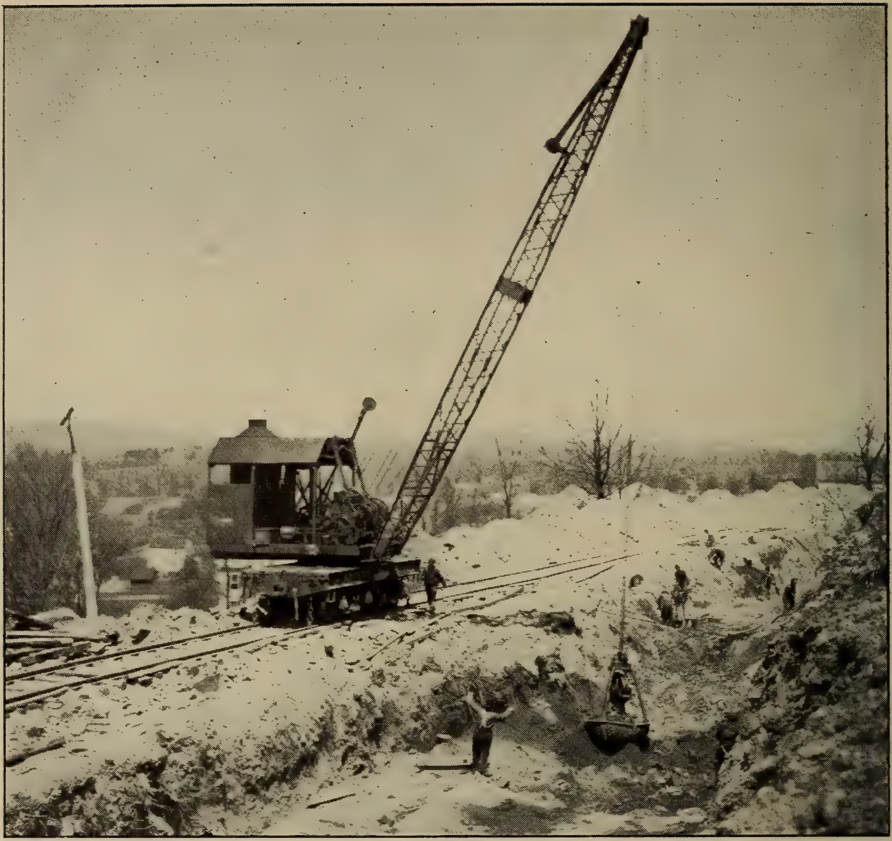
ging of the steam shovel, nor can it perform even light digging on a vertical wall. On a surface facing the sky it is suited to act. If in addition the material be not too difficult certain types of grab bucket can be depended upon to make substantial penetration during closing operation. If the material is soft the grab bucket is highly adapted to excavation. Perhaps the most notable thing about this apparatus is the simplicity of the auxiliary arrangements necessary. The grab bucket is used when swung from the end of the boom of a locomotive crane; it can be handled by a derrick; in short, wherever a block-and-tackle can be hung there a grab bucket can be arranged. It is there not dependent upon a railway track. It may be arranged in a variety of ways. This flexibility and adaptability tend to make it a high favorite with men who have to get work done.

One of the notable types is the clam-shell bucket. It is, doubtless, so called because the manner of opening and closing the two halves is similar to that of the clam. This bucket is largely used for the purpose of rehandling material. It is especially suited to deal with crushed rock or sand for concrete. Let down upon a pile of such material the jaws are operated to effect closure and seize the load. This is a matter of but a moment. It is then lifted and the auxiliary apparatus moves it to its destination. This auxiliary apparatus may be a cable-way, a derrick or some similar device. To discharge the load it is only necessary to operate the opening and closing mechanism.

The orange peel bucket consists of a number of blades, each somewhat similar to a section of the earth's surface included between two meridians and the equator. When these are arranged with their butt ends uppermost and their tips spread out somewhat one does not wonder at the name "orange peel." There is a



A HAYWARD BUCKET OF 21 CUBIC FEET CAPACITY, CLOSING ON ITS LOAD



REMOVING BLASTED ROCK WITH HAYWARD ORANGE-PEEL BUCKET

framework above the cluster of blades, within which is the opening and closing device. There may be three or four blades. This apparatus is a fine digging machine. The sharp point suitably bent digs into the material when the closing mechanism is operated. The three-bladed type has especial merit in the handling of large rocks. A bucket of this type built for the United States Government is said to be capable of handling boulders weighing from 8 to 20 tons. It is not necessary that a rock be completely inclosed. The three blades simply secure a good grip, when the rock can be carried. A three-bladed bucket is much better for such service than one with four blades, since three blades 120 degrees apart can oftener be depended upon to secure the rock in such way that all blades are in service. The load is then more likely to be evenly distributed. A very moderate-sized three-bladed bucket, having a capacity of over 21 cubic feet, has been found equal to boulders weighing as much as 3,000 pounds. This bucket was capable of excavating in shale, hard pan, and the like.

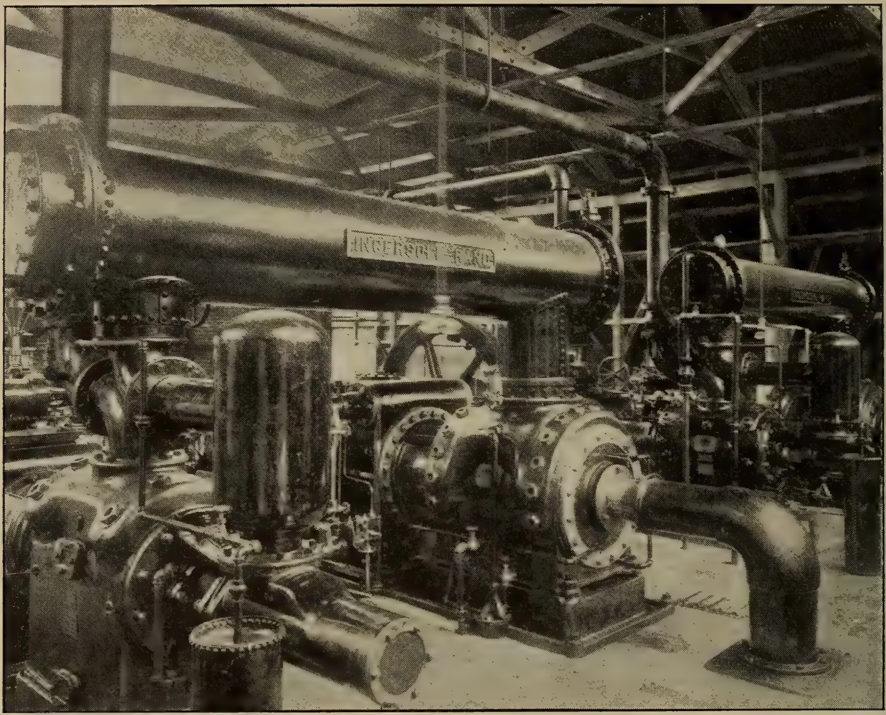
When one considers the foregoing qualifications he is prepared to learn that contractors on the Aqueduct are using both shell and orange peel buckets. Apparatus of both classes are built by the Hayward Company, 50 Church street, New York City.

### THE DIAMOND DRILLS

The diamond is excessively hard and fully capable of dealing with any rock that may be encountered. Very considerable pressure may be put

LOCOMOTIVE CRANE WITH HAYWARD BUCKET IN SAW-MILL VALLEY, ELMSFORD, N. Y.
PITTSBURGH CONTRACTING CO.

upon it while it is at work. But there must be no shocks. In order that the condition of successful operation with a diamond bit may be met it is necessary that the feed of the drill shall be absolutely uniform and that it shall be very small and at times almost microscopic in amount per turn of the drill rods. Two systems of feed are in prominent use to-day: the one is purely mechanical; the other is a hydraulic method.

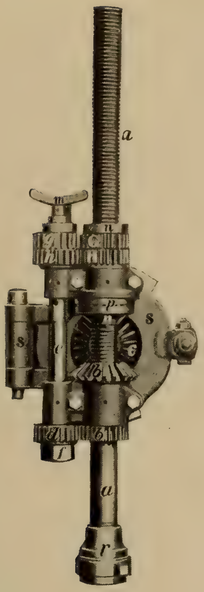


INGERSOLL-RAND AIR COMPRESSORS IN PLANT OF MASON & HANGER, CORNWALL, N. Y.

The mechanical method depends upon the principle of the differential screw. Suppose a screw and nut to be in engagement; if the nut be restrained rotationally and axially—that is, to be held absolutely fixed—right-handed rotation of the screw will carry it in an axial direction away from one, provided the threads are right handed. If the threads are left hand, right-hand rotation will have precisely the opposite effect and the screw will approach. Now, restrain the nut axially, but rotate it in a left-hand direction. The screw will recede from one. The rotation of the screw and the nut in the same direction have opposite effects on the movement of the screw. It will not be difficult now, perhaps, to see that if both are rotated at the same angular rate and in the same direction that the screw would remain fixed in an axial direction. In fact, it is the difference in angular speed that is effective in driving the screw either backward or forward. To drive it forward it is necessary—with left-hand threads and right-hand rotations—that the speed of the nut should be faster.

Perhaps the greatest advantage the hydraulic feed has over the gear feed is the fact that when conditions of hardness change at the bottom of the hole the feed varies automatically. The change in resistance induces a faster or slower penetration, the pressure remaining constant.

Some of the most difficult diamond drilling on the line of the Aqueduct has been in connection with the crossing of the Hudson at Storm King Mountain. So difficult has this work been that it can scarcely be said that the exploration is quite complete. Apparently no one knows where the ancient gorge of the river is located, nor how deep it is. The holes put down in the river itself required the provision of suitable supports for the machinery and operators. One method consisted in rigging a platform on the pipe used for the casing.



ARRANGEMENT OF DIFFERENTIAL FEED. AMERICAN DIAMOND ROCK DRILL CO., NEW YORK.

As the water was quite deep, the casing was held in position by suitable gags secured to heavy anchorages. In all, fifteen holes have been put down in the river. Only six of these succeeded in reaching bed-rock. For one reason or another the other mine had to be abandoned. The exploratory work at the crossing affords good examples of inclined holes. In all, six such holes have been put down. Two of these were bored from the river banks, one on each side. The eastern hole was inclined 30° 24′ from the vertical. It was carried down 221 feet. On the west, or Storm King side, the inclination was 24° 4′ from the vertical. This hole was taken down 566 feet. From either shaft sunk on the two sides of the river two very flat holes have been run. The upper pair of holes passed each other at about 955 feet below the surface of the river, their depressions below the horizontal being about 25°. The lower pair of holes passed each other at a depth of about 1,550 feet. The angles of depression here are about 380. The upper holes are each about 1,800 feet in length; the lower ones, about 2,000 feet. It would seem that no conditions have been uncovered by these transverse explorations indicative of doubtful results. The hole put down in the center of the river reached a point 768 feet below the water surface, when it was abandoned. There are no cases showing the character of the rock between the bottom of this hole and the 955-foot depth reached by the one part of transverse holes. That is, little or nothing is known as to this 187 feet of rock. However, the tunnel itself will be much lower down than either depth. It will, in fact, pass about half way between the two points of crossing of the pairs of transverse holes.

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# THE FUTURE OF COPPER

By George W. Colles

A GREAT deal has been said and written in these later years concerning the danger of exhaustion of the metal supplies in the earth, but little consideration has been given to the more immediate and more real probability of the increasing cheapness of production and consequent lowering of cost. This is swiftly on the way in regard to all metals, and in the case of gold does constitute, and has constituted, a real question as to the stability of existing financial systems. The present article will, however, consider the case of copper only, which, next to iron, is of the most vital importance to the industrial world.

In the early part of the last century copper can hardly be said to have been a staple commodity; at least there was no general market dealing in it, and the prices were often around around a dollar a pound. Copper mining cannot really have said to have been begun in the United States until the opening of the Calumet and Hecla mines in the early seventies, then considered a most hazardous proceeding. Copper has been mined in upper Michigan in a haphazard way some years before that time, taking advantage of the great masses of copper found, especially in the Ontonagon deposits, but up to the time of the Civil War the total production of the United States was less than 9,000 tons, and the prices about that time ranged at 40 cents to 50 cents a pound. In 1870 it had fallen to 20 cents, from which it rose just prior to the panic of 1873 to 44 cents, falling at the end of that year to 25 cents, and thence continuously declining until 1879, when it sold at 15½ cents, then the lowest on record. The trade revival of that year carried the price back to 24 cents, a price it did not reach again until 1907. From that price it steadily declined, grounding on bottom at 10 cents in the years 1885 to 1887, rising to 17½ cents in the next three years, and thence falling to 9 cents in 1894, the lowest price ever reached, but in none of its fluctuations during the 1892-1898 period did it rise above 12½ cents. It deserves notice that during all this time the electrical industry was rapidly developing, and yet it did not seem to influence materially the price of copper, notwithstanding this is now one of the most important avenues of consumption. With the industrial boom of 1898 to 1899 copper quickly rose to 19½ cents, but it is to be remembered that this was an artificial price or "corner" engineered by the promoters of the Amalgamated Copper Company, and did not last. The boom of 1907, which carried it once more above 25 cents, now an extravagantly high price, was not, as currently supposed, produced by any corner, but by the sudden fear of a shortage and a general scramble for metal by the manufacturing interests. The boom collapsed with a sudden check to business, marking the worst debacle the metal has ever had, falling from 25 to 11½ cents in about seven months.

A broad view of the situation shows a continued decline for more than a century, until the average price for recent years has been not more than one-fifth or one-eighth of what it formerly was. All this notwithstanding the continuous exhaustion of the richer deposits. The Calumet and Hecla mine, at its opening, was considered an extremely hazardous undertaking, and yet nowadays it would look like coining money could such a rich deposit be duplicated. In the meantime lower and lower grade rock has been attacked and successfully mined on the Keeweenaw peninsula, until even 18 pounds of copper to the ton, the average of the Ahmeek, is regarded as a rich lode, which is to be contrasted with the original 60 pounds or so of the Calumet.

And yet all the copper in the peninsula would not alone have sufficed to reduce the price to its present level in the face of increasing demand for the metal. About twenty years ago the new camp of Butte was turned from a silver to a copper-mining centre, and as such has steadily grown in importance. Yet this source could not be regarded as other than temporary. About the same time as Butte, the Bingham camp of Utah appeared above the horizon no larger than a man's hand, and has grown to overmastering importance. The fact that a deposit containing only ½ to 2 per cent. combined copper could be operated at a profit was something that mine investors refused to believe, until the owner of the original claims of the character, Colonel Wall, of Salt Lake City, had done many years of missionary work and actually erected a mill to prove it. These are the deposits that now appear before the entire copper-mining industry by producing thousands of tons of copper annually.

The whole secret of the matter is

this: that, whereas all former copper mines extracted the ore from narrow lodes blasted by hand at great expense underground, the new so-called "porphyry" mines mine the country rock on the surface of the ground by means of steam-shovels in the same manner as the iron mines of Minnesota. The cost of extraction per ton is thus reduced to 40 or 50 cents, as against $1.50 to $5 by the old way; and the quantity which may be extracted is limited only by the size of the mills which can be erected and the number of steam-shovels which can be operated at one time. Mills of heretofore unheard-of capacity, 10,000 to 20-000 tons a day, have been erected not simply in Utah, but also in Nevada over the great Ely deposits, and capable of producing copper at such prices as only the richest of mines can compete with. And the end is not yet. Since the successful issue of the Utah experiment, new porphyry deposits of like tenor are being discovered in other places. In the Gila Valley district of southern Arizona, the Ray, Chino, Miami and Inspiration companies are all building or planning to build enormous concentrating mills and blocking out hundreds of millions of tons of ore. The copper from all this ore will be produced probably at an average cost of 8 to 9 cents per pound, and will undoubtedly more than equal in quantity all the other copper produced in this country, which has averaged 10 to 11 cents per pound.

The porphyry mines are not the only accessions of recent years to the world's copper resources. Numerous low-grade deposits are being developed in the boundary district of British Columbia, just over the line from Spokane, and in the Cananea district of Sonora, Mexico, not far from the Arizona line. The wonderfully rich Cerro de Pasco mines of the Peruvian plateau, which have been developing under the auspices of the Morgan syndicate, are just coming into production, and the equally rich deposits of the Copper River district, Alaska, must in the coming years, as soon as the politico-legal difficulties are straightened out, be expected to yield an important contribution to the world's supply. Central Africa, too, furnishes great deposits of unprecedented richness which are being attacked, and the Katangas mines are already nearly ready to supply the market with 25,000,000 pounds a year as a beginning.

From all these premises there is obviously but one unprejudiced conclusion that can be drawn, viz., that the progress of the mining art, combined with geological science, has enabled copper to be produced in such quantities as the world needs at a lower price than heretofore, and that copper must, in consequence, continue to decline in value. We cannot, of course, predict what the price will be next year or any year, as some sudden demand coming from some new use of copper, or new boom in building construction, for example, may outstrip the *temporary* capacity of the mines; but this result cannot be other than fleeting. A reduced cost must, in default of some source of control, such as exists in the steel industry, as bolstered up by the tariff, necessary lead to a reduced price.

In view of this probability it becomes of interest to inquire what the likelihood is that such a source of control—in other words, a copper trust—shall be brought about. Undoubtedly immense financial interests are being brought to bear to accomplish that end; but it must be borne in mind that the situation of copper is far different from that of iron. Quite aside from the fact that the copper industry is not, and could not be, controlled by a tariff on the metal, as is the case with iron and steel, the copper industry is too widely dispersed to be controlled for long by a single set of men. The stockholders of the native mines of America are scattered among small holders all over the country and in the aggregate represent an average of 6 per cent. dividend capacity on about a billion dollars capital. Aside from this are the two important facts that a large and increasing proportion of the world's supply is coming from other countries, and that the production of the raw material is not bound up with the manufacturing industry, but takes place in innumerable smelters, and is consumed in the practically raw state by a vast number of users of different classes.

There is, moreover, one impregnable and vital fact which must necessarily prevent not only the artificial jacking up of the price of copper as has been done with steel, but even its increase to any extent, unless the consuming market should take on a radically different aspect from that which it bears at present; as might be produced, for instance, by the discovery of some new art requiring a large proportion of the annual production of the metal, and in which no substitute for copper could be employed. This is the rise of aluminum as a competitive metal, which is a movement hardly begun as yet. That aluminum can and will be substituted for copper in electrical machinery, more particularly in the long-distance transmission lines which are to form so great a feature of the electrical development to come, is a question only of price. It has been estimated in a general way that aluminum at 25 cents is economically equivalent for electrical uses to copper at 13 cents, and that aluminum can be profitably produced at 25 cents, even in the present stage of the art, is also an acknowledged fact, since it can be purchased at that price in quantity. Until two years ago the Hall patents, which cover the only practical process for producing aluminum, practically made the latter industry a private preserve, and both limited the production and upheld the price; but now this process is public property there can be no question that we are on the eve of a great development in this industry, since it is free to all, and the source of supply, if silicious minerals be considered such, are almost limitless.

It is true that, as thus far developed, the art of aluminum requires bauxite, a hydrate of the metal, as a raw material, and that the silicate compounds, which are so universally in distribution and form so large a portion of the earth's crust, have not yet been made commercially available, but on the other hand it should be remembered that progress in this direction has been held in check until the present time by the aforesaid patents. We cannot doubt that electro-chemisistry will easily succeed within a few years in solving this problem, and when that happens aluminum as a metal will take the place in commerce comparable with that now held by iron and copper, and in doing so will encroach largely on the domain of both, while concurrently establishing a new and peculiar domain of its own.

Of course, the progress in the art of aluminum production, which is sure to take place, necessarily presages a decline in its price, which will necessarily react on the price of both iron and copper. To what extent this fall in price will go, of course, depends on the enlargement of the field as the fall continues; but it is a matter which seriously concerns everybody directly interested, either as miner, investor or manufacturer, in the copper industry, and should give caution to all those who are accustomed to take a long look ahead.

# THE EARNING POWER OF CHEMISTRY

### By Arthur D. Little*

IT may fairly be claimed for chemistry that it is at once the most fundamental and the most comprehensive of all the sciences. Its province, in the classical definition of Ostwald, is "The study of the different forms of matter, their properties, and the changes which they undergo." Thus defined, chemistry embraces the material universe, our solar system, the most distant stars and the flaming nebulæ no less than the dust speck within the universe, on which we live and which we call the earth. It includes within its subject matter the physical basis of our own bodies and of those of every living thing upon the earth. It is directly concerned with the air we breathe, the water we drink, the food we eat, the materials upon which we expend our labor, and the things which we buy and sell.

The world in which we live is a different world to every individual in it, as it has been a different world to every generation of the race of men. To no other generation have its confines been so opened out and broadened as to our own. To the man congenitally blind, tapping his way along the curb, a modern city is a place of sounds and measured spaces; to one who sees, it becomes a world of light and movement and ever-changing shades. Plymouth Rock is a very ordinary piece of granite to one who knows not its history; to the better informed it stands as the symbol of that adventurous spirit and uncompromising virtue on which the foundations of our country rest. To the world at large coal-tar is a black and evil-smelling nuisance; to the eye of the chemist it is replete with all the potentialities of the rainbow.

So it happens that the world as viewed by the chemist presents an aspect different in many ways from that in which it appears to the mind not chemically trained. As the astronomer perceives in the movements of the stars a relationship and co-ordination to which the average man is blind, and deduces from them generalizations by which both the intellectual and practical life of the community are profoundly influenced, so the chemist, who may be regarded as the astronomer of the infinitely minute, studies the movements and interchange of atoms and the structure of the molecular systems which result therefrom. In other words, the astronomer interprets the universe in terms of certain units, which are the heavenly bodies, while the chemist seeks his interpretation in terms of the ultimate particles of which matter is composed, whether they be molecules, atoms, ions or electrons. And, since the different forms of matter, in their flux and flow, together constitute the universe, the properties of matter and the changes which these properties undergo are of compelling interest and importance to each one of us in every activity of our lives.

We live immersed in an ocean of air and we draw this air into our lungs approximately eighteen times a minute. The quality of this air, its temperature, pressure, humidity, the minute impurities which may be present, affect our comfort and well-being in many ways. It supports the chemical processes of combustion by which our existence is maintained no less than those upon which we are chiefly dependent for light and heat and power. The nature of this all-enveloping atmosphere of air has always been a subject of speculation, though to little purpose before the advent of chemistry.

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* A public lecture to business men delivered June 29, 1911, under the auspices of the Indiana Section of the American Chemical Society.

Modern chemistry had its birth in the eighteenth century study of the air and its relation to the processes of respiration and combustion. Professor Ramsay has said that "To tell the story of the development of men's ideas regarding the nature of atmospheric air is in great part to write a history of chemistry and physics." The story is one which has reached its culminating interest in our own most recent times. For $35 one may now buy apparatus for reducing air to the liquid form and study the properties of matter at temperatures nearly as low as that of interstellar space.

Within the memory of the youngest undergraduate in chemistry the brilliant researches of Ramsay, Raleigh and other chemists have disclosed the presence in the air we breathe of five new gases of remarkable and in some respects unique properties. To one of these, neon, we now confidently attribute the long-mysterious phenomena of the aurora borealis. Tubes containing highly rarefied neon may become as commonplace to our descendants as candles were to our forefathers. They glow with a rich, mellow, golden light on the passage through them of an electrical discharge.

The heavy toil of life in mine disasters would be unsupportably heavier were it not for the Davy lamp, the fire-damp indicators, the rescue outfits and the regulation of explosives, all of which have become possible only through the growth of chemical knowledge. Ventilating systems as applied to theatres, halls and dwellings are based on chemical studies of the rates and causes of increase in the carbonic acid content in the air of rooms. The proportion of sulphur permissible by law in illuminating gas finds its justification in similar studies on the air in rooms in which such sulphur-bearing gas is burned.

The chemical and biological study of public water supplies, which received its first systematic development little more than twenty years ago at the hands of Drown and Mrs. Richards in the laboratories of the Massachusetts Institute of Technology, has been the means of saving countless lives throughout the world and has led to such understanding and made possible such control of sources of pollution as to almost justify the statement that for every case of typhoid fever some one should be hanged. Chemistry can now determine in advance of use the suitability of a given water supply for use in boilers or for the requirements of any special line of industry, as paper-making, dyeing, cloth finishing, brewing, and so on. Furthermore it supplies the means for correcting undesirable characteristics in a water supply, as by use of filtration apparatus, coagulants, water-softening systems and the Moore method for the destruction of the algae which in many waters are the cause of unpleasant tastes and odors.

Nowhere is the practical value of chemistry in its relation to the affairs of every-day life more strikingly demonstrated than in connection with our food supply. Chemical fertilizers are in large and constantly increasing measure responsible for the enormous total of our agricultural products. The whole fertilizer business is under the strictest chemical control, and the farmer buys his fertilizer on the basis of a knowledge of its composition and effective value which puts the average purchasing agent of a manufacturing company or public service corporation to shame. The Association of Official Agricultural Chemists, and the laboratories of the agricultural colleges and experiment stations throughout the country are doing more to keep down the cost of living than all the law-makers we send to State capitols and Washington.

One of the most insistent of the demands of growing plants is that for nitrogen in form available for plant food. A small proportion of the necessary supply of nitrogen in the assimilative form is derived from the manure of farm animals and from animal wastes of various kinds, but for many years the world has depended upon the nitrate beds of Chili as the chief source for this indispensable element of plant growth. It is bad enough to be tied in this way to a single far-away deposit, but the situation becomes alarming when we discover that this deposit can hardly meet the world's demand for nitrate for another twenty years. One may contemplate the Malthusian theory with indifference or even with disbelief, but here is a condition not to be gainsaid. The world must do something to meet it within twenty years or the world must make up its mind to starve. Fortunately for the world the chemists are already doing something. They have recognized that 33,800 tons of nitrogen are pressing down upon every acre of land and have boldly attacked the problem of rendering available such portion of this inexhaustible supply as the world may need. The methods employed have been daring and brilliant in the extreme.

In 1785 Cavendish, in a paper before the Royal Society, describes the production of nitric acid by the passage of an electric spark through air. A hundred years later Bradley and Lovejoy at Niagara Falls, by drawing air through an apparatus by which 400,000 arcs were made and broken each minute, demonstrated the possibility of the commercial manufacture of nitrates from atmospheric air. Birkeland and Eyde in Norway pass the air through furnaces in which it comes in contact with enormous flaming and rotating arcs. Rossi in Italy brings the air in contact with highly incandescent material of special composition. Although by these several processes nitrate has been produced by thousands of tons it is doubtful if the artificial product can yet compete with Chili niter. Even now, however, the margin is not a wide one and the results already accomplished amply prove that when our agriculture begins to feel the pinch of a falling nitrate supply the chemist may safely be relied on to meet the situation. This assurance is rendered doubly sure by the fact that a solution of the problem along altogether different lines is already nearly or quite within our hands. Dr. Frank has shown that by heating calcium carbide, itself a comparatively recent product of the laboratory, in a stream of nitrogen there is formed a new compound, calcium cyanamide. The practical interest in this compound depends upon the fact that when exposed to a current of steam it decomposes into ammonia and carbonate of lime, and that the same reaction takes place slowly in the soil when the cyanamide is mixed therewith. Since the nitrogen in ammonia is directly assimilable by plants, and since calcium carbide requires for its production only lime and coke and power, we may view without serious concern the approaching failure of the Chilian nitrate beds.

But it is not only on the side of agriculture that chemistry touches our food supply. Chemistry pervades the packing industry, reducing the cost of food by utilization of by-products of the most varied character, from oleomargarine to glycerine and soap and from soap to pepsin and adrenalin. To Atwater and his co-workers we owe our knowledge of the energy-producing value of different foods in the human economy, and to Wiley and those other chemists behind him on the firing line we are indebted for the far-reaching benefits of the Pure Food Law.

Carbon disulphid made in the Taylor electric furnace has preserved the wine industry of France by destroying the phylloxera, as it is ridding our own fields of prairie dogs and our elevators of rats and mice. Bread-making and brewing are coming each year more and more within the recognized domain of chemistry, which is at the same time greatly enhancing the value of our staple crop by the increasing production of glucose, corn oil and gluten. Exactly one hundred years ago Kirchof discovered the inversion of starch to glucose by dilute acids. To-day the United States alone is richer by $30,000,000 a year by reason of that discovery.

The relation of chemistry to the clothes we wear is perhaps less obvious but still of the first importance. More land is planted to cotton, and cotton itself is cheaper because chemistry has taught the planter how to secure increased yields by proper fertilization and how to obtain increased profits by utilization of the cottonseed for oil and cattle feed. Chemistry is even now developing new sources of profit for the planter by adapting the short fiber adhering to the ginned cottonseed hull to the making of smokeless powder and the stalks of the cotton plant to paper-making.

The woolen industries are dependent upon chemistry for the processes of separating the pure fiber from the grease and dirt with which it is associated in the raw wool and for the methods of working up this wool waste into oleic acid, soap, lubricating oils and potash and ammonia salts, as well as for the process of carbonizing by which the wool is separated from the burrs and other vegetable material with which it is admixed in the fleece.

Many of the most brilliant achievements of chemistry have been directly concerned with the textile industries. A little touch of chemistry to cotton yarns and fabrics in the mercerizing process gave the world what is practically a new textile fiber—cotton with the beauty and luster of silk. A history of absorbing interest replete with struggle, the capture of positions of temporary advantage, the constant shifting of the fighting line, crushing defeats and signal victories might be written of the development of the bleach and alkali industry, upon the products of which the textile manufacturer depends for the finishing of his goods. We see the pathetic figure of Le Blanc dying in the poorhouse after enriching the world which Napoleon was devastating. No less interesting in its human and scientific aspects is the long story of the coal-tar colors in which chemists take so large a measure of justifiable pride. An investment of $750,000,000 follows Perkin's discovery of mauve.

Less notable, but nevertheless an industrial achievement of the highest order, is the very modern development of artificial silk, which, though made from wood pulp, far surpasses in brilliance and beauty the finest product of China and Japan. Closely related thereto is the artificial horse-hair of which so large a proportion of women's hats are made, and the still more recent artificial bristles of cellulose acetate with which you may have brushed your hair this morning.

A complex series of chemical reactions has its origin in the striking of every match, and civilization, as we know it, could hardly exist without the modern facilities for securing artificial light. For the extraordinary extension of these facilities during the past century the chemist has mainly been responsible. The immortal Faraday selected "The Chemistry of a Candle" as the subject matter of a classical series of lectures to audiences of children. From the rush candle and the tallow dip to the candles of stearin and paraffin is in itself a long journey, the milestones on which were set by Scheele, Chevreul, Heintz and Tilghman.

The refining of petroleum involved the solution of many difficult chemical problems. The Chicago fire is said to have been started by Mrs. O'Leary's cow, which kicked over a kerosene lamp. In those days, however, it was not necessary to invoke the cow to start a conflagration with kerosene. Much of the lighting oil upon the market at that time would flash below 100 degrees F. We owe our present safety in the use of kerosene largely to the work of Professor Chandler.

The production of illuminating gas is wholly a chemical process. When coal gas was first employed for lighting the Houses of Parliament the members might be seen gingerly touching the pipes to discover if they were not indeed hot from carrying such flame. That gas is now so cheap is due in large part to the development by Lowe of the chemcal process for making water gas by passing steam through a bed of glowing coals and to the chemical processes for gas enrichment. By the Blaugas system illuminating gas is now produced in liquid form and distributed in steel bottles to isolated consumers like so much kerosene.

The gas mantle, by which the illuminating power of gas is raised from 16 to 60 candles on a consumption of 3½ feet an hour, constitutes one of the most signal triumphs of chemical research. Certain sands found in Brazil and known as monazite sands had long been a happy hunting ground for chemists by reason of the number of rare metallic elements to be found therein. They seemed to be a sort of chemical garret where everything not otherwise used up during the process of creation had been stowed. Dr. Carl von Welsbach was investigating the rare elements in these sands some thirty years ago and studying their spectra. It occurred to him that a better flame for his purpose, or rather a better distribution of the metallic vapor in the ordinary Bunsen flame, might be secured by distributing the metallic compound through the substance of a bit of cambric. He dipped the cambric in a solution of the salts, suspended it in the flame, burned off the cotton, and found that the fragile ash glowed with an amazing brilliance. So came into being the gas mantle which has revolutionized and saved the illuminating gas industry, though not until the initial discovery had been followed by years of the most painstaking and refined research.

In the development of electric lighting the chemist has played a part scarcely less important than that of the electrician.

The arc light was first shown by Davy between charcoal points and was maintained by the current developed by the action of chemicals in the enormous battery of the Royal Institution. To Faraday, whose achievements in electricity have overshadowed his renown as a chemist, we owe the discoveries upon which our modern methods of generating electricity are based. The early history of the incandescent lamp is a chronicle in equal measure of the difficulties of finding a proper material for the filament and those of producing the requisite degree of vacuum in the bulb. Both problems were solved by chemistry, which first supplied the carbon filament made by dissolving cellulose, squirting the solution into a thread of the required diameter, drying and carbonizing the thread and thereafter flashing in an atmosphere of hydrocarbon vapor to deposit carbon on the filament precisely where and in exactly what proportion its original inequalities of resistance to the current made necessary. More recently Whitney and other chemists working in the same field first greatly raised the efficiency of the filament by the process of metalizing, so-called, and have since given us lamps of an altogether new order of usefulness by employing new materials, as tungsten, for the filament.

The second great problem, that of securing rapidly and cheaply the necessary high vacuum in the bulb, was solved in the most elegant manner by the extraordinary Malignani process. Malignani placed within the tubulature leading from the bulb and connecting the bulb and pump, a minute quantity of red phosphorus, started the pump and roughly exhausted to about 2 mm. of mercury. He then sent through the filament a current so heavy as to bring the filament to intensive incandescence and cause the gaseous residue within the bulb to faintly glow so that the bulb was filled with a luminous blue haze. He then sealed off the pump by fusion of the walls of the tubulature below the phosphorus, and with the bulb still glowing touched the tip of the blowpipe flame to that portion of the tubulature wall against which the phosphorus rested. With the vaporization of the phosphorus the blue haze instantaneously disappeared and an almost perfect vacuum was secured within the bulb. The process is not one of oxygen combustion, as might on first thought appear, and its ultimate mechanism was not understood until many years subsequent to its discovery.

The improvements in incandescent lamps in the last ten years have resulted in the saving of $24,000,000 a year in the cost of lighting as compared with the cost of equal illumination by the older types of lamp.

To the art of illumination Wohler and Willson have contributed the calcium carbide and acetylene found on every automobile and in a hundred thousand isolated homes; Pintsch and Blau have developed separate systems permitting the transport of illuminating gases in steel tanks for the lighting of trains and houses; to Hewitt we owe the mercury lamp, to other inventors the flaming arc, to Nernst the high efficiency lamp which has his name, and, long before them all, to Bunsen the blue-flame burner utilized by Welsbach and which constitutes the basic element in every gas stove.

I have endeavored in this cursory and most inadequate survey to indicate something of the extent to which chemistry contributes to the satisfaction of the demands and needs of every-day life. The earning power of the science becomes more directly apparent in its relation to general industry.

Let us consider a few concrete examples of the earning power of chemistry. A large pulp mill found itself with over 100,000 cords of peeled wood piled in its yard and this wood was beginning to rot. A few thousand gallons of sulphite liquor sprayed over the pile from a garden hose killed the fungus and saved the pile. The same mill was losing 23 per cent. of its wood as barker waste. Laboratory trial proved that any excellent quality of paper could be made from this waste, all of which in this mill is now profitably worked up. Other mills still throw 20 per cent. or more of their initial raw material away. The mill was cooking in 16 hours. Laboratory cooks were made in 7½ hours and the time of the mill cook reduced to 10. Finally, by a proper spacing of the digesters, the production of the plant was brought from 97 tons a day to 149 tons.

Cylinder oils generally cost about what you are accustomed to pay. Plants which employ a chemist pay from 19-27 cents. Manufacturers who do not need a chemist commonly pay 45 cents, 65 cents, or even, if they know their own business very well, $1.50 a gallon. There is probably not a large plant in the country in which, if it is not already under chemical control, the lubrication account cannot be cut in two. In the engine room of one large cement plant the average monthly cost for lubricants had been $337. It is now $30. A concern paying 37 cents a pound for a special grease which the superintendent needed to run the mill now buys on specification for 5½ and the mill still runs. Another company within our knowledge saves $12,000 a year on cutting oils alone.

In a plant near Boston using 2 tons a week of special steel rolled very thin, their chemist was able in about two years to reduce the cost of the material from 80-40 cents a pound, while at the same time standardizing and greatly improving the quality of the steel. We recall savings of $2,100 a year on wrapping paper, $3,600 on boiler compounds, $6,800 on a minor article of supply, $100,000 a year on a single raw material. Professor Duncan, in his fascinating and suggestive book, "The Chemistry of Commerce," says: "On three separate occasions the writer has visited the same glass house to see the workmen bailing out a lake of violet spoiled glass from the same immense tank, and all because it was deemed by the foreman 'theoretical' to have the manganese analyzed in order that its quality might be adjusted to its oxidizing value. Thousands of dollars were thus wasted and thousands more lost through failure of the firm to fulfill its contracts on time, and all of it could have been saved at the cost of, say, $10 for a simple analysis."

Chemistry points out the only proper way to buy supplies, which is on the basis of their industrial efficiency by means of specifications defining the quality desired and rigid tests to make sure that quality is secured. Independent estimates by those in exceptional positions to know place the efficiency value of supplies as purchased and used by American manufacturers at 60 per cent. of what it should be.

Comparatively few American manufacturers light their cigars with $20 bills. It is too slow a method of burning money. They prefer to burn it by shovelfuls, so they burn it in the boiler room. They forget that in ostensibly buying coal they are really buying heat, and they pay good money for slate and sulphur balls with no knowledge of the actual number of British thermal units they are receiving for a dollar. Perhaps they depend upon a trade name, ignoring the fact that coals from different mines in the same district vary greatly, as does also coal from the same mine. Moreover coal, like some other things, is not always true to name. A few years ago the Boston School Committee decided to buy its coal on specification. It had previously bought "New River coal of the best quality," and that definition of its desires was included in the specification, which, however, also included a chemical definition of what coal bearing this name should be. When deliveries were made by the same dealer who had previously supplied school coal they proved to be an inferior grade of Pennsylvania coal with sulphur in some samples running up to 6 per cent. When the contractor was called to account, he admitted that he did not know the State in which New River coal originates nor the transportation route by which only it could come to Boston. His comment to the committee was, "I don't see what you are fussing about; it's the same coal you've always had." Later when the temperature in the piles in a certain school ran up 90 degs. in one day he was called upon to remove all coal delivered by him to schools in that district and substitute therefor New River coal, which he did at heavy loss to himself and corresponding gain to the city.

Important as are the losses in the initial purchase of coal, they are small compared with those which attend its burning. Many a mill owner looks out of the window and sees, without knowing, his dividends go up the chimney. Under well-regulated conditions of combustion the flue gases should contain not less than 12 per cent. of carbonic acid gas. They frequently contain no more than 3 per cent. This means that for every ton of coal burned under the latter conditions more than 52 tons of excess air are heated to the high temperature of the flue gases. Chemistry meets these conditions by analyzing the flue gases and regulating the draft as indicated by the percentage of carbonic acid found. At $2.25 a ton, which is much below the average price, the fuel bill of the United

States was over $1,000,000,000 in 1910. Of that amount chemistry could easily have saved $100,000,000.

Chemistry aids the manufacturer who will listen to her teachings in countless other ways. It substitutes a rigid control of processes for the guesswork and uncertainty of the rule of thumb. It increases the productivity of labor by supplying more efficient processes.

In the sulphur mines of Sicily young boys called *carusi* climb with groans and curses for 400 feet bearing in a stifling atmosphere 40-pound loads of sulphur ore upon their backs. In Louisiana, thanks to Frasch, two concentric pipes are driven to the ore, a hot solution of calcium chloride is forced through one pipe to melt the sulphur, which is then pumped to the surface through the other, at a trivial fraction of the cost of raising the ore in Sicily.

In the old days of making paper the rags were piled in a heap, moistened and allowed to stand for weeks until fermentation had proceeded far enough to soften them. Now they are boiled with lime for a few hours. They used to be bleached by the slow action of the sun and dew as they were spread upon the grass. They are brought to better color now over night by bleaching powder. Cutting tools made from high-speed tools multiply the output of the lathe and planer. The addition of 1 per cent. of calcium chloride to the electrolyzing bath doubles the yield of potassium chlorate.

Chemistry aids the manufacturer by standardizing his product and reducing seconds and rejections. It costs just as much to tan goat skins into seconds as into firsts, though seconds bring a third as much. Chemistry even comes to the front bearing ammunition during an advertising campaign. You may remember the offer of a blowpipe and a bit of character coupled with the information that if your paint was a lead paint, as the advertiser believed it should be, you could quickly prove its quality in the laboratory of your kitchen by reducing from the paint a little pellet of metallic lead. You do not see that advertisement now. It disappeared about the same time that some one else informed the world that zinc paints are "unalterable even under the blowpipe."

Nowhere, however, does chemistry render such efficient service to the manufacturer as in turning to profit waste and nuisance. To this phase of its service we shall return again.

To quote once more Professor Duncan:

"During the next five years the small manufacturer who is swept out of existence will often wonder why. He will ascribe it to the economy of large scale operations, or business intrigues or what not, never knowing that his disaster was due to the application of pure science that the trust organizations and large manufacturers are already beginning to appreciate."

A few of us have been surprised, and none more than the railway managers themselves, by the well supported statement before the Inter-State Commerce Commission that the railroads of the country could save $300,000,000 a year by the application of scientific management to the operation of their properties. Every chemist who has studied the problem is well aware that the entire amount in question could be saved through utilization of the proved results of chemistry alone.

Abraham S. Hewitt is authority for the statement that the Bessemer process has added $2,000,000,000 yearly to the world's wealth. By far the greatest portion of this increment has come through the economies which this process of steel-making has rendered possible in transportation.

Our own study of car painting practice on twenty-one electric roads has developed the fact that 50 per cent. of the cost of materials and labor is wasted and more than 50 per cent. of the time spent by the cars in the shops is unnecessary.

The classic work of Dr. Dudley as the head of the laboratories of the Pennsylvania system has gone far to standardize railroad practice throughout the country. Few, even among railroad men, realize how greatly the whole community is in his debt. His specifications cover rails, soaps, disinfectants, oils for signal and for lubricating, paints, steel in special forms for every use, car wheels, cement, signal cord and every detail of equipment. He has made the transportation of life and property cheaper, safer and more expeditious by reason of his application of chemistry to the problems of railroad management.

In a recent address Dr. Frankforter, voicing the opinion of every thoughtful chemist, said: "The United States is the most wasteful nation in the world; wasteful in living, wasteful in manufacturing, and wasteful in conserving its natural resources." So heedless and appalling is this waste that the mind trained in chemistry stands aghast. I have lately visited a Southern lumber mill which burns 1,900 cords of wood a day in its incinerator. There are 200 such burners in the country limited in destructiveness only by the amount of material sent to them. From such wood chemistry is prepared to extract 3 gallons of turpentine a cord, 10 gallons of ethyl alcohol, or paper pulp to the value of $20. We waste each year 500,000,000 tons of coal and each day a billion feet of natural gas. With peat deposits fringing our entire Eastern coast we pay $4 a ton for coal delivered on the bog. Beehive coke ovens flame for miles in Pennsylvania and excite no comment, while the burning of a $1,000-house would draw a mob. We fill the Merrimac River with wool grease, making it a stench, while the towns along its course buy soap and fertilizer and lubricants from Chicago, Chili and Pennsylvania. We burn coal tar in Massachusetts and import coal-tar colors at high prices from Germany. Over the great Northwest we burn each year 5,000,000 tons of flax straw, while we pay $40 a ton for imported paper stock from Norway. In the South 300,000 tons of paper fiber of the highest grade are burned with the cottonseed hulls to which it is attached or used with them to adulterate cattle feed. Cornstalks to an incalculable tonnage rot or are burned each year while chemistry stands ready to convert them into feed containing 30 per cent. of sugars on the dry basis, or into alcohol for light and power. Waste molasses is sold for 3 cents a gallon or dumped into the stream, while alcohol sells for 40 cents a gallon. Skim milk is fed to hogs or thrown away because no one has the enterprise to extract its casein, which is worth more than beefsteak for food.

In the face of such conditions we still meet young men who would inform us that the day of opportunity is past. The truth is that opportunity is knocking, not once but insistently and long, at every entrance to the chemist's laboratory.

Nowhere is the earning power of chemistry better shown than in its ability to transform cheap raw materials into products of exceptional value. A cord of wood is worth perhaps $10 with a dry weight of a little over a ton. Its value, therefore, is about half a cent a pound. In the form of chemical fiber for paper making half the weight is lost, but the remainder is worth 2¼ cents a pound. As paper it finds a market at 4 cents. Made into artificial silk by more refined chemical processes it commands $2 a pound, while as cellulose acetate bristles it is worth $4.

Many of our great industries are founded on minute chemical facts. Goodyear drops a bit of gum mixed with sulphur on a hot stove and the rubber industry results. The fact that silver salts happen to blacken when exposed to light is responsible for a corporation with $35,000,000 capital on which the earnings are over 20 per cent. a year. The dipping of cotton yarn in caustic soda while tightly stretched has revolutionized the manufacture of the better grades of cotton textiles. Because the chemist learns that glycerine treated with nitric acid becomes explosive our army engineers are able to separate two continents. Becquerel, having placed a bit of uranium upon a photographic plate in a black paper wrapper, finds on development that the plate has blurred. The observation leads Professor and Madame Curie to study similar actions by uranium ores and presently the thought of the world is enriched by altogether new conceptions of the constitution of matter, and our minds are awed by the magnitude of forces previously unrecognized.

Two classes of securities find a ready sale in Massachusetts—3½ per cent. bonds and gold bricks. It is not an easy matter to raise money for a sound chemical proposition which promises 20 per cent. Much the same conditions undoubtedly prevail throughout the country. Boston, which invested largely in sea water gold, the Hickman machine for converting starch to cane sugar, and the electrical process by which spruce wood was transformed into Australian wool with the grease in and the burrs attached, is just now figuring its losses on synthetic rubber. It left to other communities the formula of the Altoona cobbler for burning ashes, the process for converting water into kerosene, and the Lamoine diamonds. Men who turn a box of strawberries upside down and require a pastor's certificate of character from the office boy rush into misapplied chemistry with never a thought of expert investigation or advice. The pity is the greater when one realizes, as every chemist does, the generous scale by which are measured the rewards of chemistry properly applied and wisely administered. Ten years ago a Massachusetts company with a capital of $20,000 was organized to conduct a manufacture based on chemistry; two years ago it charged off $700,000 on real estate and equipment; to-day is has a surplus of over $1,000,000. The great Badische Anilin und Soda Fabrik, the Elberfeld Company, Brunner, Mond & Co., the E. I. duPont de Nemours Powder Company, Meister, Lucius & Bruning, the Solvay Process Company, and many others well known to every chemist are among the most profitable industrial organizations in the world. The one thing lacking for an enormous development in this country of equally profitable enterprises based on chemistry is a reasonable appreciation by our business men of the earning power of chemistry.

The ordinary investor who may safely trust his own judgment in matters involving cotton, wheat, mortgages, railroad shares or telephones is not equipped by training or experience to decide upon the validity of propositions involving chemistry. He must, if he would avoid disaster, rely upon the opinion of disinterested experts. Such opinion should cover the soundness of the chemistry involved, the state of art relating to the manufacture, the patent situation, the available market, the nature and extent of competition, the supply of raw material, the stage of development of the process, the cost of plant and the costs of production. These last should be itemized and the basis for conclusions regarding every item should be fully stated. Large allowances should invariably be made for depreciation and in most cases equally liberal allowances for contingencies. Secret processes should be left to the fool and his money.

In this environment and on this occasion I cannot forbear making a brief concluding reference to that organization of chemists which now enjoys your hospitality. At Northumberland, Pa., there lies the body of an obscure English dissenting clergyman, who went through life on a salary of £30 a year, although he had enriched the world by the discovery of oxygen. It was around the grave of Priestley on July 31, 1874, that the idea of the American Chemical Society first took form in the minds—and may I add the hearts—of a few American chemists, met to do honor to his memory. Subsequent meetings were held in New York at the home of that Nestor among American chemists, Prof. Charles F. Chandler, until on April 20, 1876, the society was formally organized. From a feeble organization of distinctly local character, with only 200 members in 1887, it has, through the service and self sacrifice of a long series of devoted officers, become the largest chemical society in the world, with 5,500 members, and is to-day the most powerful influence in America for the advancement of chemical science. Its claim upon the loyalty and support of every American chemist can no longer be denied or set aside. With equal justification it may appeal to the whole community for recognition and encouragement.

There are in the country at least 100,000 doctors and nearly 125,000 lawyers. There are only 10,000 chemists to carry on a work incomparably more important than litigation and no less beneficial than medicine to the life of the community if that life is to be worth living. Some measure of the mere material benefits which chemistry can offer may be found in the fact that the annual production of the chemical industries of the United States is already nearly equal in value to our agricultural products. Let us, however, not forget that these benefits have come, as many more will follow, because chemists have never faltered in pursuing truth for years through the labyrinth of difficult researches with no better guide than the slender and often broken thread of an hypothesis. Turgot has said: "What I admire in Christopher Columbus is not that he discovered the New World, but that he went to look for it on the faith of an idea."

# THE MINING INDUSTRY AND THE PUBLIC LANDS*

**By George Otis Smith, Director of the United States Geological Survey**

THE increasing share which the United States Geological Survey has been asked to take in the public land administration by the Interior Department has brought many of the problems connected with the public land laws more directly to the attention of those charged with the work of this bureau. For over thirty years, however, these problems have interested the Survey geologists, who have had exceptional opportunities for first-hand observation in nearly all the important mining districts of the country, and for almost as long a period the engineers of the Survey have been in touch with the irrigation and power developments in the public land States. This intimate experience with both field conditions and administrative problems justifies an expression of opinion which may be appropriate to this occasion.

The objects to be sought by amendment of the public land laws are, first, purposeful and economical development of resources for which there is present demand with retention of such control as may insure against unnecessary waste or excessive charges to the consumer, and second, the reservation of title in the people of all resources the utilization of which is conjectural, or the need of which at least is not immediate. The means that are essential to the attainment of these objects are, first, the classification of the public lands; second, the separation of surface and mineral rights; and third, the disposition of the lands on terms that will secure the highest use, enforce development and protect the public interest. Legislation based on these principles will not only secure the positive benefits of immediate utilization, but will also avoid the evils of speculative holdings of lands by fictitious use or by admitted non-use, for the future enjoyment of the unearned increment or of the profits of monopolization. With actual development made a condition of possession, and with land classification and separation of estates made preliminaries of disposition, the present-day utilization by individuals or corporations and the reservation to the people for future use become at once possible without conflict of interests.

The classification of the public land is essential to the administration of not only such laws as express the principle of separation, but also of those whose purpose is to promote the highest use of the land. Land classification is, first of all, the determination of the best use to which each particular portion of the public domain can be put, and by the organic act of March 3, 1879, this duty was specifically imposed upon the Director of the Geological Survey.

Under the withdrawal act of June 25, 1910, classification is made possible in advance of disposition, and disposition can be postponed to await needed legislation.

The second step, both in principle and practice, appears to be that of making possible by legislation the separation of surface and mineral rights whenever the two estates have values which can be separately utilized. A notable advance in public land legislation was the passage of the acts of March 3, 1909, and June 22, 1910, which provide that patents issued thereunder grant title to the surface of the land only and thus permit the agricultural development, while at the same time the United States retains title to the underlying coal deposits.

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*An address at the Twenty-first Anniversary of the Michigan School of Mines, Houghton, Mich., August 9, 1911.

On the subject of water-power legislation the position of the Geological Survey is essentially that set forth in January of this year in a report addressed to the Secretaries of the Interior and of Agriculture by a joint committee representing the two departments. The legislation there outlined would provide for lease of public and reserved lands of the United States valuable for water-power development for a fixed term, not to exceed fifty years, with moderate charges for use and occupancy of the land, and revocable only upon breach of conditions or on account of the charge of excessive rates to consumers. These leases should be identical in terms, whatever the department under which they are granted, with joint and uniform regulations governing all matters relating to water-power development of land belonging to the United States. Provision should also be made for periodic and equitable readjustment of charges, transfer of leases, preferential rights to renewal, and compensation for improvements at the termination of the leasehold. The law should specifically recognize water-power use as dominant and both insure to the lessee undisturbed occupancy of the land needed for such use and reserve for future utilization all the land believed to possess value for water-power development, these lands to be designated by the President but to be open to other entry, subject to this reserved right, wherever separation of the water-power use and other use is possible.

The chief advantage of land withdrawal and classification lies in the essential relation to the principle of proper disposition of the public domain, the real purpose of public land administration being to secure such reservation or disposal of the people's land as will assure its highest use. The question of amendment of the present laws relating to the disposition of coal, oil, gas, and phosphate deposits on the public domain is recognized as fairly before the public by the specific mention of these minerals in the Withdrawal Act.

The coal land law is unquestionably the most satisfactory of the present mineral land laws, in that it admits of the placing of an adequate valuation upon the deposits, and in the administration of this law the purpose is not only to base the appraisal price upon the quantity and quality of the coal present and to give consideration to every known physical and commercial factor affecting the value of the deposits, but also to make the selling price approach as nearly as possible the present purchase of a royalty under a leasehold. Thereby it is intended to permit purchase for immediate development and at the same time to prevent, or at least discourage, purchase for long-time investment or for monopolization. So many factors, however, require consideration that an ideal adjustment of the values is well-nigh unattainable for many, if not for most, coal lands, and on this account a strong argument may be made for support of the lease over the sale system. Under leasehold it would be comparatively easy so to adjust the relationship between ground rental and royalty as to prevent the acquisition of coal deposits until such time as their development should be profitable. On the other hand, it is possible, under the present law, and it is the policy in its administration, to readjust the prices from time to time, either by reduction to encourage development in special cases, or, more commonly, by raising the price on account of increased value, due to new discoveries or to changed commercial conditions. Hardly less important, moreover, is the better control possible under a lease system, although against the advantage of such control must be weighed the cost of Federal management and the possibilities of inefficient administration, or even maladministration. The present coal land law, however, has one serious defect, which should be remedied if a leasing law is not enacted. The restriction of area that may legally be acquired to a maximum of 160 acres for an individual and 640 acres for an association is not in accord with good mining practice. The fixed charges on the cost of a modern coal mine, provided with the up-to-date equipment necessary to conserve life and property and to assure maximum recovery are too high to be assessed against the tonnage of so limited a tract, especially if the coal seam is of moderate thickness. A law designed to promote the practical utilization of coal deposits, whether the system contemplates sale or lease, must provide for the holding of a large enough unit to permit the opening and equipment of a modern mine and to warrant its operation on an economical scale. Without such provision for commercial operation too great an advantage is secured to the land-grant railroads and large coal companies already in possession of considerable areas of high-grade coal.

The present uncertainty whether the phosphate rock of the public land should be entered under the lode law or under the placer law is conclusive evidence of the need of legislation. As a matter of fact, neither of these laws is more applicable to the acquisition of beds of phosphate-bearing limestone than it would be to that of coal beds. The realization that the phosphate deposits are more extensive than was known or suspected when the Survey geologists began land classification work in Idaho and Wyoming does not lessen, but rather increases, the urgency for a leasing law which will provide for the utilization of this large supply of mineral fertilizer, so as to meet both present and future needs.

The most urgent need of legislation for the disposition of mineral deposits is in the case of oil and gas. It is most apparent that the placer law, which is none too well adapted to meet modern conditions in mining placer gold, is wholly inadequate as a method of dealing with public oil lands, inasmuch as the discovery of oil is a late stage in the exploration and development of the land claimed under the law. Thus, large expenditures, extending over several months, if not years, are necessary before any right is acquired against the Government, and during all this time there is lacking any legal protection of the oil prospector against unscrupulous claimants or competitors better backed by capital. The need for remedial oil legislation is somewhat less acute than it was a year ago, by reason of the passage of the act approved March 2, 1911, the effect of which is to validate a class of claims which, while clouded by the construction which the Department was forced to place upon the misfit placer law, under which title to oil lands must now be made, were *bona fide,* in that the inception of their development antedated the oil land withdrawals. This enactment was in accord with the spirit of the Withdrawal Act, which provides for the protection of equities already established.

The need for a better law is, however, imperative, and the legislative action demanded by the situation should not be limited to an attempt to revamp the general placer law, but should be the enactment of an altogether new measure, especially adapted to provide for the sane and equitable development of this industry in the future. First, the new law should authorize the issue of exploratory permits, granting to individuals or associations the exclusive privilege of occupation, the sole condition of such a grant being diligent and adequate prosecution of development work, measured by the expenditure of fixed sums within certain periods, with possibly the payment of a small fee to the Government in lieu of such expenditure during the first six months. The issue of this permit should preferably be limited to one to each citizen or association of citizens, although after the lapse or surrender of such permit the former holder should be allowed to again apply for an exploratory permit. In the second place, the law should provide that, upon discovery, the holder of the permit be given a leasehold title with a royalty varied to meet local and actual conditions. The "wild-catter," or prospector in unproved country, whether such unproved territory is classified on geological evidence as oil land or not, should be given special privilege to offset his greater risk. This privilege might take the form of an increased acreage, held both under permit and under lease, or a practical exemption from the payment of royalty, merely a nominal rental being charged under the lease. The chief advantage of the leasehold for oil over a fee-simple title lies in the prevention of monopolization through large holdings. Such large holdings without production would be guarded against by a ground rental sufficiently high to discourage the acquisition of lands except for immediate and continued development, although provision should also be made in the lease for surrender under terms which would protect the Government. This indirect control of development would be preferable to the direct enforcement, by forfeiture, of continuous production, which should be avoided because of the danger of disturbing the delicate equilibrium between supply and demand. Transfers of interest, under either permit or lease, should be permitted because of the absolute necessity in most instances of securing capital for both drilling and operating an oil well. The law, however, should set forth the purpose of such control of transfer, which would be to provide protection for the original locators, most of them men of small means, and more especially to secure the prohibition of too large holdings of Government leases by big companies.

Proposed amendments of the well-established laws relating to metalliferous minerals always raise the warmest discussion. With the opinion of mining men in general favoring revision of the mining laws of the United States and with commission after commission appointed by various bodies to suggest improvements, the statutes have remained practically unchanged for nearly forty years, while the geology of ore deposits and the technology of metal mining have made marvelous progress.

The law of the apex has proved more productive of expense litigation than of economical mining. In many of the more recently established and more progressive mining districts this statute has been made inoperative by either common agreement or compromise between adjoining owners. Its repeal could not affect established equities under patents already granted, but would render possible more certain property rights in large mining districts as yet undiscovered, where new and valuable claims will be located 100 years from now. The unit of disposition should be the claim, preferably square, limited on its four sides by vertical planes, and of a size sufficient to allow the miner occupying two contiguous claims to follow the vein or lode to considerable depth, even if its dip is only 45 degrees. Such definition of a mining claim is found practicable in both Mexico and British Columbia, and in the latter country the change from the apex law was effected without trouble or confusion.

The same knowledge of natural conditions that leads to the suggestion of a repeal of the law of the apex forces the further suggestion that discovery of ore in place cannot be made universally a prerequisite to the location of a mining claim. Geologic study of ore deposits has furnished examples in a number of regions where the present law cannot be complied with, although rich deposits exist underground and their extent can be more definitely surmised than in most cases where ore is discovered at the surface. To meet such actual conditions the law should provide for the acquisition of metalliferous mineral land classified as such upon the basis of adequate geologic evidence, whether actual outcrops are present or not.

Most important, perhaps, in any amended mining law would be provision for enforced development, a principle expressed, it is true, in the present law but not effective in its workings. A requirement of actual use as a condition of occupancy of mineral land cannot be regarded as either novel or radical. As regards the large acreage of undeveloped land in many mining camps to which patent has already been issued, it is perhaps true that the situation is without relief, unless the Western Australia plan is adopted, whereby the Government steps in and permits mining under a lease, the proceeds of which are assessed, collected and paid over to the owner. The principle invoked seems to be that no property owner can rightfully oppose the development of the State.

In the case of unpatented claims a remedy should be sought for what has been termed "the paralysis of mining districts," and the rigid requirement of annual assessment work should be made actual and effective by inspection and supervision, in order to put an end to the present procedure of allowing a claim to lie idle for practically two years after its location, not to mention the many localities where claims are held year after year with only perfunctory compliance, or even without any performance of assessment work, a type of local disregard for law that is in striking contrast to the observations accorded to the district customs and regulations of earlier days, whereby the right of possession was made absolutely dependent upon continuous operation.

The remedy, then, for the existing evil of idle mining property must be sought either in the adoption of leasehold, under which the Government can enforce operation, a system which fully attains the desired end of promoting mining development in Australia and New Zealand, according to the report made in 1907 by Geologist Veatch, of this Survey, to the President, or in the thorough revision of the existing system. Radical amendment to the present law would be necessary in order to secure something more nearly approaching equality of opportunity. Some limitation should be put on the number of claims which an individual can locate in each mining district, and the prevention of monopolization would be furthered by the rigid enforcement of assessment development. The record of claims kept by a local official elected by the miners should be reported promptly to the nearest land office in order to furnish the Federal Government with a notice of the intention of the claimant, and thus to initiate the operation of effective inspection, the purpose of which would be to enforce the use and development of mineral land as contemplated in the law.

Whatever the details that may characterize this or that amendment to the public land laws, the essentials to be sought are development of those resources for which there is present need and the protection of the other resources for which there is no immediate demand. To this end the lawmakers, in my opinion, should concern themselves more in retaining such control as will prevent either non-use on the one hand or waste on the other, than in devising means of increasing the public land receipts by heavy royalties on the producing coal mine or hydro-electric plant. Tax, instead, the idle property. Through the full development of the mineral industry, the nation can secure indirect benefits far in excess of any direct profits in the form of fees or royalties.

Mr. Edwin M. Herr, whose portrait we give in this issue, was elected president of the Westinghouse Electric and Manufacturing Company on August 1, 1911. He was born at Lancaster, Pa., in 1860, and, after a common school education and two years' practical experience in railroad work, he entered the Sheffield Scientific School of Yale University, from which he was graduated in 1884, having worked during his vacations in the shops of the Pennsylvania Railroad Company at Altoona.

After an apprenticeship in the shops of the Chicago, Milwaukee & St. Paul Railroad he entered the service of the Chicago, Burlington & Quincy Railroad, passing successively through the positions of mechanical draughtsman, assistant engineer of tests, engineer of tests, superintendent of telegraphy, and division superintendent.

From 1890 to 1892 Mr. Herr was division master mechanic of the Chicago, Milwaukee & St. Paul Railroad, and from 1892 to 1894 he served as superintendent of the Grant Locomotive Works at Chicago. He then became superintendent of motive power and machinery on the Chicago & Northwestern Railroad, following which he held the same position on the Northern Pacific Railroad.

Since 1898 he has been connected with the Westinghouse interests, having become assistant general manager of the Westinghouse Air Brake Company in September of that year, and general manager on November 1, 1899. On June 1, 1905, Mr. Herr was elected first vice-president of the Westinghouse Electric & Manufacturing Company, from which position he was raised to the office of president on August 1, 1911.

EDWIN M. HERR,

President Westinghouse Electric and Manufacturing Company

See Reverse Side.

INDEXED

# CASSIER'S MAGAZINE

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## TITANIUM STEEL

**By J. F. Springer**

THE chemist's list of the elements is quite a long one, containing many names that have been, until recent years, to all intents and purposes, unknown in industrial fields. What significance in the commercial world could have been attached to chromium, manganese, tungsten, vanadium, silicon, molybdenum, a few years ago? To-day every one of them stands for something real and important in the practical affairs of life. However, no metal or substance, whether recently investigated or not, promises to become a real rival of iron and steel. Iron is still king; and, so it would seem, is going to remain so. The effect upon iron of the coalescence with it of some other element is often marvelous. A very slight percentage of carbon produces a beneficial effect upon its tensile strength. If no more than 1 per cent. of carbon is added, we have in effect quite a different material from pure iron. From this we should learn the lesson that an alloying substance need not always be present in considerable quantity. Thus, the addition of a very minute percentage of vanadium to steel results in a marked change. Now, the alterations in the characteristics of steel made by substances which were but a short time ago well nigh unknown are to-day insistently claiming recognition. Chrome steel, for example, is a tool steel capable of attaining an especially high degree of hardness upon suitable heat treatment. Vanadium steel is a material having, when properly treated, an enormous tensile strength. Again, titanium has a wonderful effect on steel. It is the purpose of this article to direct attention to some of these.

Titanium is itself an element. In the pure state it has few or no applications, so far as the present-day industrial world is concerned. It has a very high melting point. Further, it is very difficult to isolate. Fortunately, it is neither necessary nor advantageous that the steel manufactures should have it in the pure state. As all steel must contain iron and carbon, we shall be able to make use of an alloy of titanium with these substances when adding it to the mass of steel. We are thus able not only to get our titanium without having recourse to the difficult process of isolation but to melt it at a low temperature. A ferro-carbon alloy containing 10 to 15 per cent. titanium and half as much carbon will dissolve without trouble in a molten mass of steel. There is thus no difficult metallurgical procedure to be followed when making the addition. The steel

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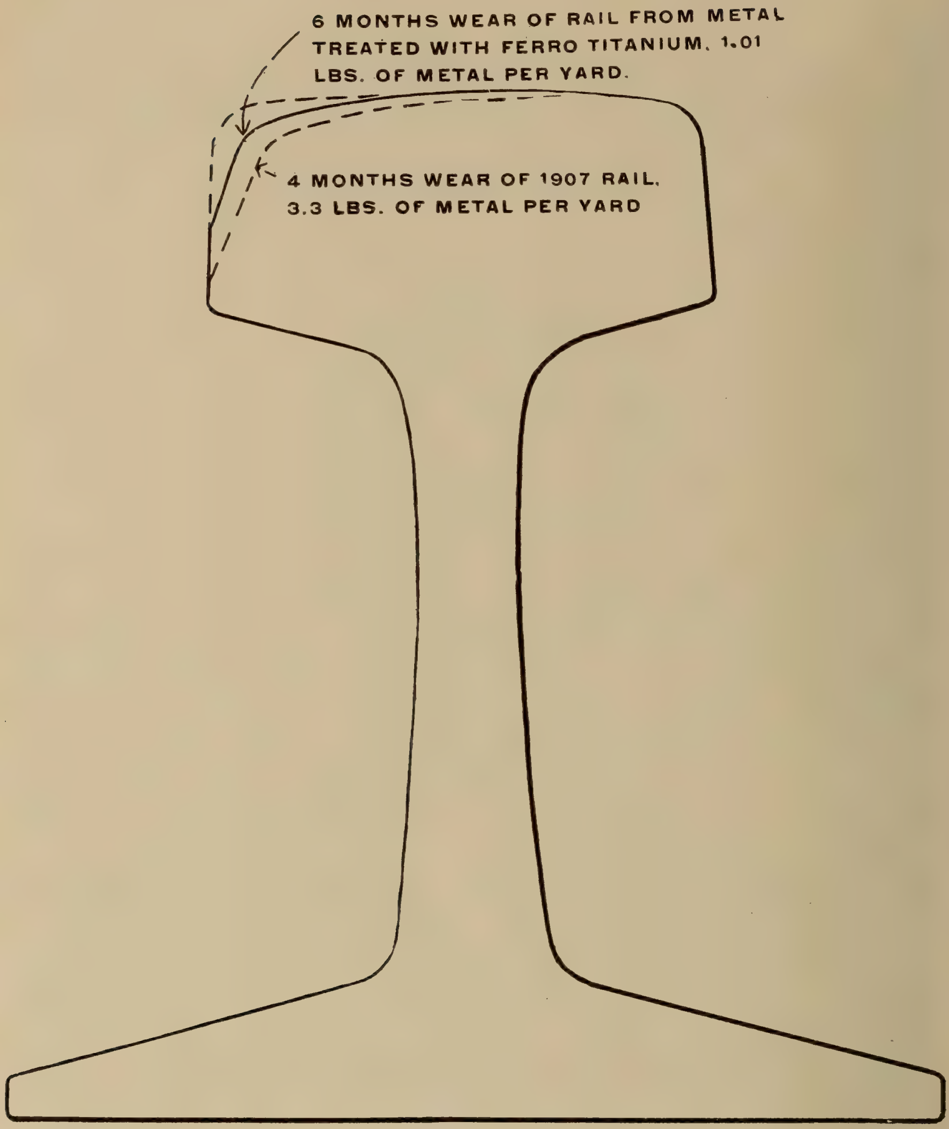
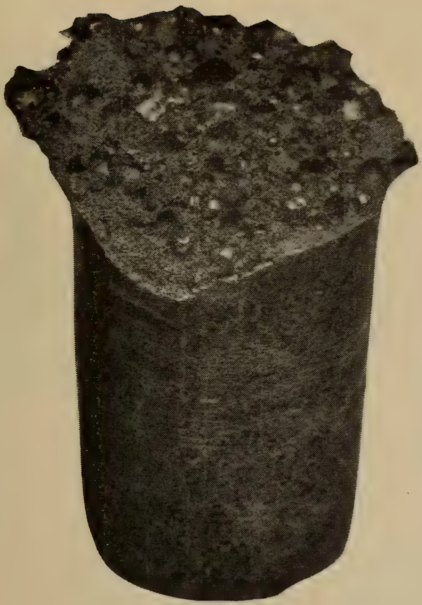

6 MONTHS WEAR OF RAIL FROM METAL TREATED WITH FERRO TITANIUM, 1.01 LBS. OF METAL PER YARD.
4 MONTHS WEAR OF 1907 RAIL, 3.3 LBS. OF METAL PER YARD

COMPARISON OF FOUR MONTHS' WEAR OF BESSEMER RAIL, OF 1907, AND SIX MONTHS' WEAR OF FERRO-TITANIUM BESSEMER RAIL, OF 1908, ON NEW YORK CENTRAL LINES

maker will, of course, take strict account of the amount of carbon he is putting in along with the titanium.

One of the first things to notice is that a mass of molten steel treated with titanium will have its temperature increased. That is to say, if we take two similar masses of steel from the same heat, one of which has been treated, and the other not, and test for temperature after the lapse of, say, two hours subsequent to pouring, we shall find the titanium steel to be the hotter. This result is, no doubt, to be ascribed largely to the fact that titanium has a great affinity for oxygen. It breaks away from the carbon and iron with which it is alloyed and unites with any free oxygen within reach. We have here the proc-

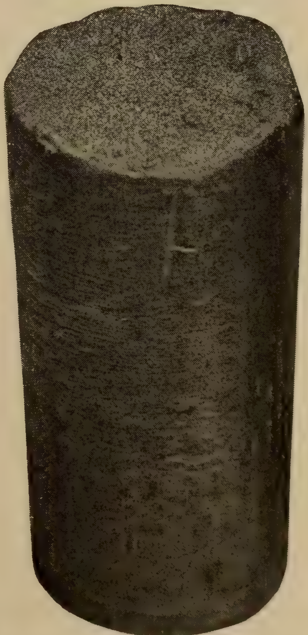


A POOR GRADE OF PLAIN CAST IRON UNTREATED

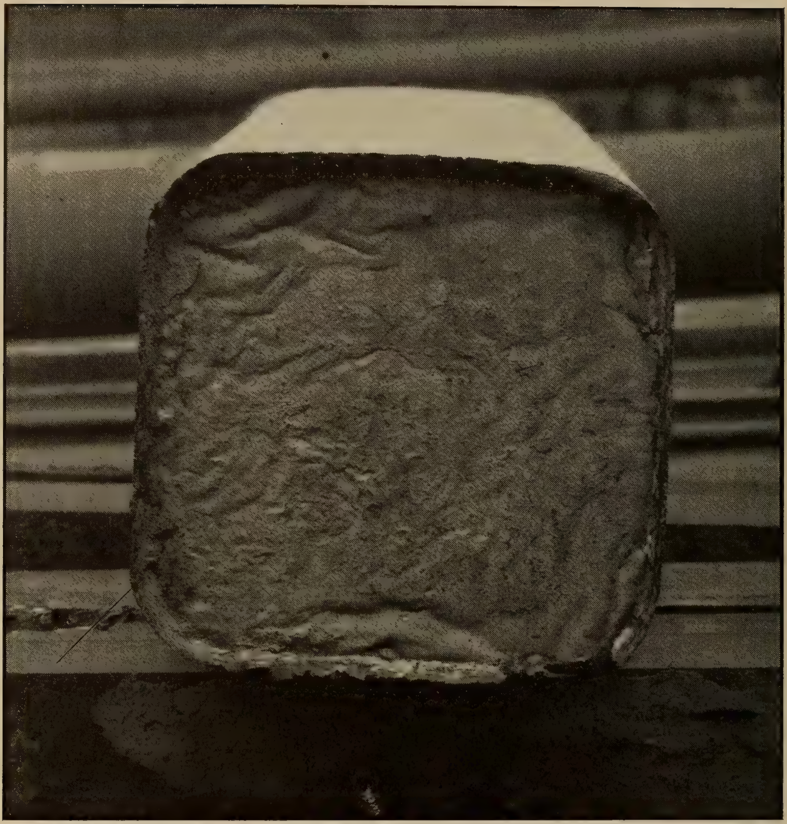
ess of ordinary combustion. Further, if sufficient titanium is present, the excess seems to break up other metallic oxides which may be present and to effect a union with the oxygen. There is here, I suppose, both a loss as well as an addition of sensible heat. Probably, however, the accession of heat is greater. Titanium has really a very great eagerness for union with oxygen. If metallic titanium is burnt in oxygen gas the combustion takes place with great energy—greater, perhaps, than is the case with any other substance. Now, manganese and silicon have each a marked affinity for oxygen. Apparently, however, it is not sufficient to make certain the complete elimination of oxygen from the bath of steel. If we wish to get rid of the residue of oxygen, we must, so it would seem, employ a further means. Titanium appears to be a means capable of effecting this deoxidation perfectly.

Now in much the same way as it operates with oxygen, titanium deals with nitrogen. There are, however, many substances which have pronounced affinities for oxygen, so that there is some choice in selecting an absorber of free oxygen and reducer of oxygen compounds. But nitrogen is so inert a substance that it is not easy to effect its elimination from the steel bath. And yet, according to some investigators at least, it is very essential that nitrogen be gotten out. Titanium has a real affinity for this gas. Indeed, titanium can be burnt in an atmosphere of nitrogen. It is claimed that titanium is the only elementary substance of which this can with certainty be said. It is said that the introduction of a titanium alloy in the steel bath is followed by the formation of a stable nitride. This nitride rises to the surface or into the slag, when it may be removed.

Further, titanium is thought to operate beneficially upon certain slags caught or occluded in the mass of the steel. Thus, in the process of steelmaking, slags composed of silica, oxide of iron, alumina, lime, magnesia, are often formed. These are frequently lacking in fluidity at the temperature of the bath, the result being that they do not rise properly to the top of the steel. Now, it seems that when titanium oxide is formed we



CAST IRON OF A POOR GRADE TREATED WITH TITANIUM ALLOY



TOP OF TITANIUM RAIL INGOT

have obtained a substance which has the effect upon the other oxides of rendering them more fluid. The effect of titanium oxide (titanic acid) in lowering the fusion point may be illustrated by the following example. Some slag was collected from the top of a titanium steel ingot, which was found upon analysis to contain 6.74 per cent. of $Ti O_2$. The fusion point was ascertained to be 1,250 deg. C. A similar slag, but containing about 13 per cent. of titanic acid, was found to have a fusion point of 1,190 deg. This property of capability of communicating fluidity to other slags would seem to be quite important. Thus the Maryland Steel Company reports that 0.25 to 0.30 per cent. of oxide of iron and other slag was present in rail steel untreated by titanium, but that rail steel when so treated was found to be practically free from impurity. The same company states that the use of manganese, silicon, aluminum, etc., for the purpose of eliminating slag is unsatisfactory, as they unite with oxygen and form $Mn O$, $Si O_2$, $Al_2 O_3$, etc., which are not only slags themselves, but are apt to be occluded in the mass. Titanium is rarely found in the metal which has been treated with it. Titanium oxide must, therefore, escape, possibly because of a higher degree of fluidity.

It will be seen from what has already been said that titanium acts as a "scavenger." Further, it does not, like many scavengers, leave unpleasant traces of itself. This is what appears to be its character. If, finally, it is all fully justified, we have here a wonderful assistant to the steel man-

SIDE OF TITANIUM RAIL INGOT

ufacturer. When we add to this the fact that the effects of titanium can be secured at a trifling cost we have promise of a great commercial future for this substance.

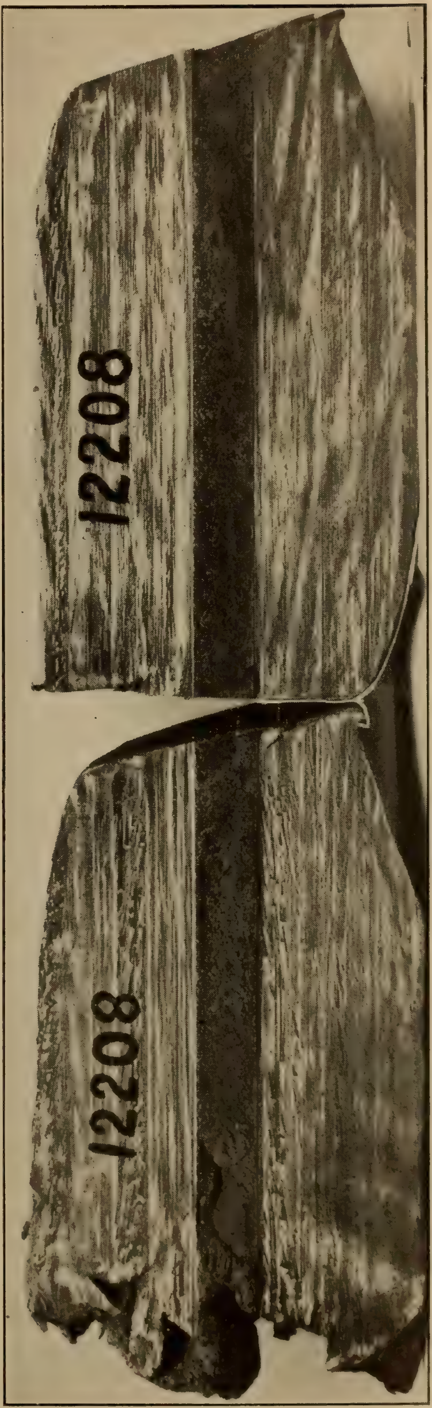
The presence of oxygen in steel is due to the processes of manufacture which are in general commercial use. Oxygen is used for the purpose of getting rid of impurities. Thus, in the Bessemer procedure, atmospheric air is blown through the molten mass to eliminate the carbon, etc. In the open-hearth procedure air is likewise

BOTTOM OF TITANIUM RAIL INGOT

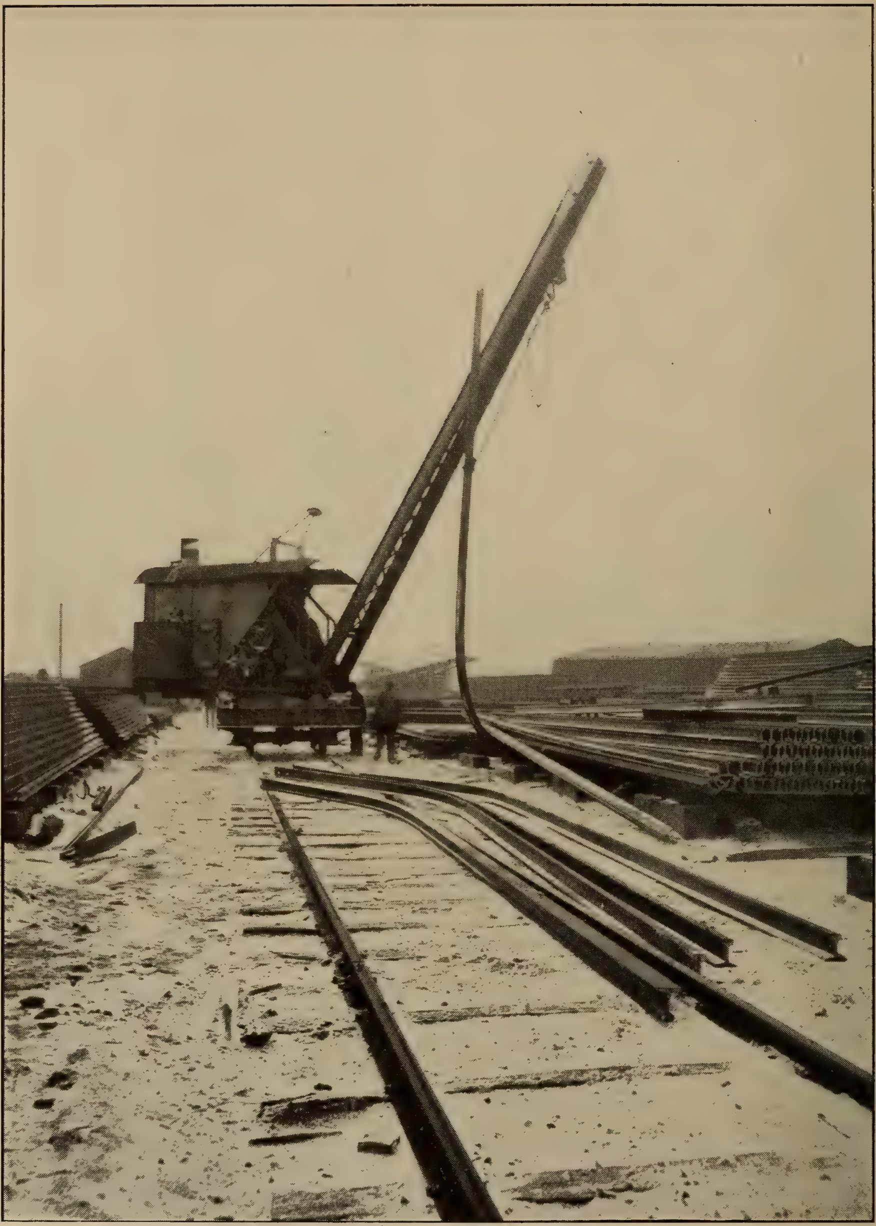
CONDITION OF RAILS AS TESTED AT KESSLER'S CURVE, CUMBERLAND DIVISION, BALTIMORE & OHIO RAILWAY

employed, although in a much slower way. No doubt the nitrogen is introduced principally, if not entirely, from the air which is used for its oxygen content. Both gases are said to be quite harmful. Oxygen, whether it occurs as $Fe\,O$ or $Fe_2\,O_3$, seems to produce brittleness and also to occasion the presence of blowholes. Professor Le Chatelier regards nitrogen as quite a damaging impurity in steel. He says that the presence of nitrogen to the extent of 0.02 to 0.035 or 0.045 per cent. in certain steels is enough to cause the metal to break asunder without elongation and reduction of area of cross-section. It is said that a nitrogen percentage of no more than 0.030 or 0.035 is sufficient to destroy the elasticity of hard steel. This result is found in the investigations of H. Braune, and seems to confirm the statement of Le Chatelier above. Further, Braune states that a 1.00 per cent. carbon steel containing 0.030 per cent. nitrogen becomes brittle and useless, even though untempered. Rail steel is usually a mild Bessemer product. E. von Maltitz found nitrogen present in such steel in the percentage of 0.013 to 0.014. The same steel when treated with titanium disclosed only about one-third these nitrogen contents. It seems that when Bessemer steel is overblown the nitrogen percentage rises. This we can understand because of the presence of this gas in the air used for blowing. Ordinarily such steel discloses a nitrogen content ranging from 0.012 to 0.022. One investigator reports an increase to 0.032 in steel overblown for three minutes. Professor Le Chatelier, speaking of an exceedingly mild steel containing only 0.06 per cent. carbon, says that the presence of a nitrogen content of 0.07 to 0.08 per cent. gives rise to an elongation extremely small, or even zero. In steel of moderate carbon, the elongation ranges from 0.04 to 0.05 per cent. He regards nitrogen as the controlling cause. For eliminating this substance titanium seems almost without a competitor. Apparently tungsten will not unite and give a nitride. Molybdenum has been experimented with in powder form exposed to a current of nitrogen, the temperature being 1,200 degs. C., without getting a combination. Vanadium is, apparently, the only possible rival at present. Even if it should be found to be equal the present expense is comparatively large. The cost of titanium is very moderate indeed. Further, the temperature required by vanadium for union with nitrogen appears to be a high one; whereas titanium unites with nitrogen at about 800 degs. C. or less.

Titanium is now obtainable in two principal forms. In both, the principal constituent is iron. Silicon, in a percentage ranging from 0.35 to 1.00, also occurs in both. The difference with the carbon content: In the one the carbon varies from 5 to 8 per



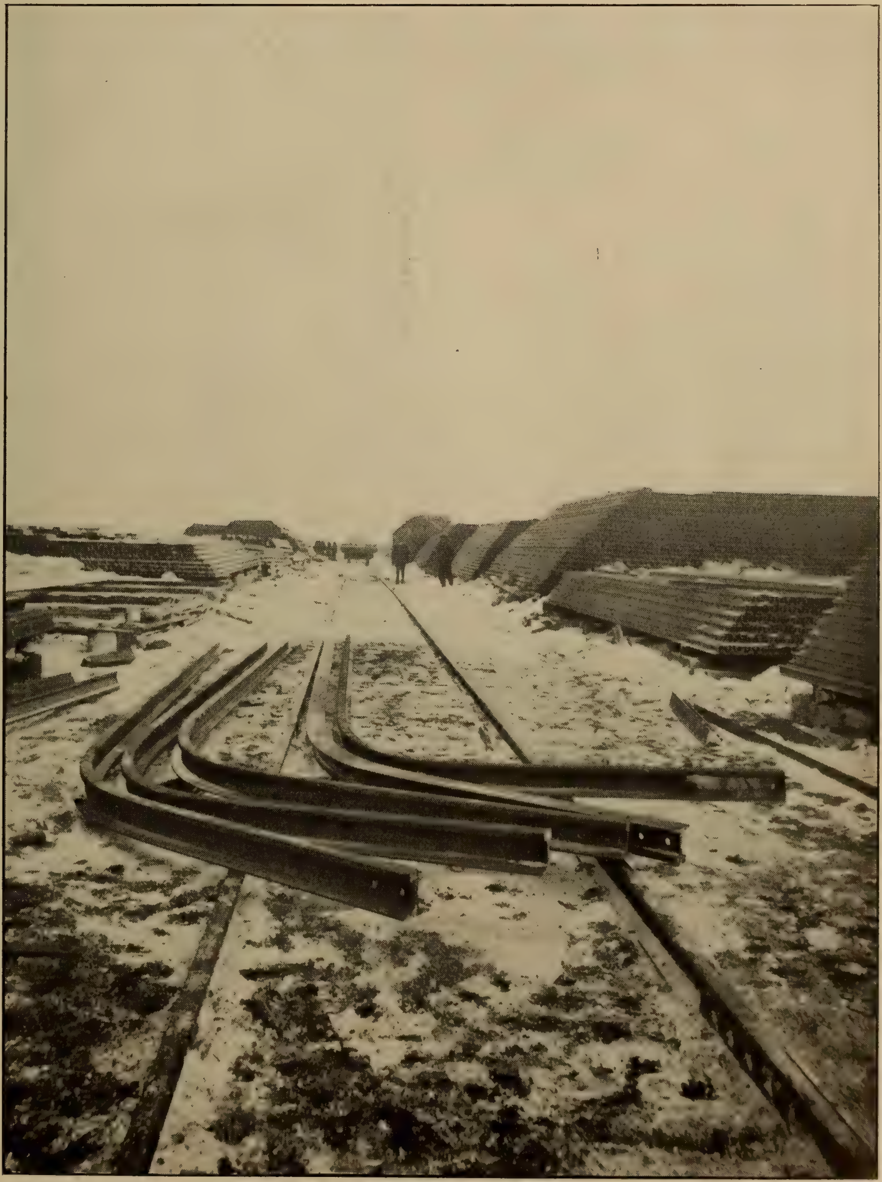
FIRST AND SECOND CROP TAKEN FROM TOP OF A TITANIUM RAIL INGOT



BENDING OF TITANIUM RAILS BY CRANE HOIST WITH RAIL UNDER PILE

cent.; in the other it is less than 1 per cent. The titanium percentage in both ranges from 10 to 15. The non-carbon alloy is more expensive. It is used for special steels, and is unsuited for use with iron. The reason for the unsuitability with iron is probably because of a higher melting point of the non-carbon alloy.

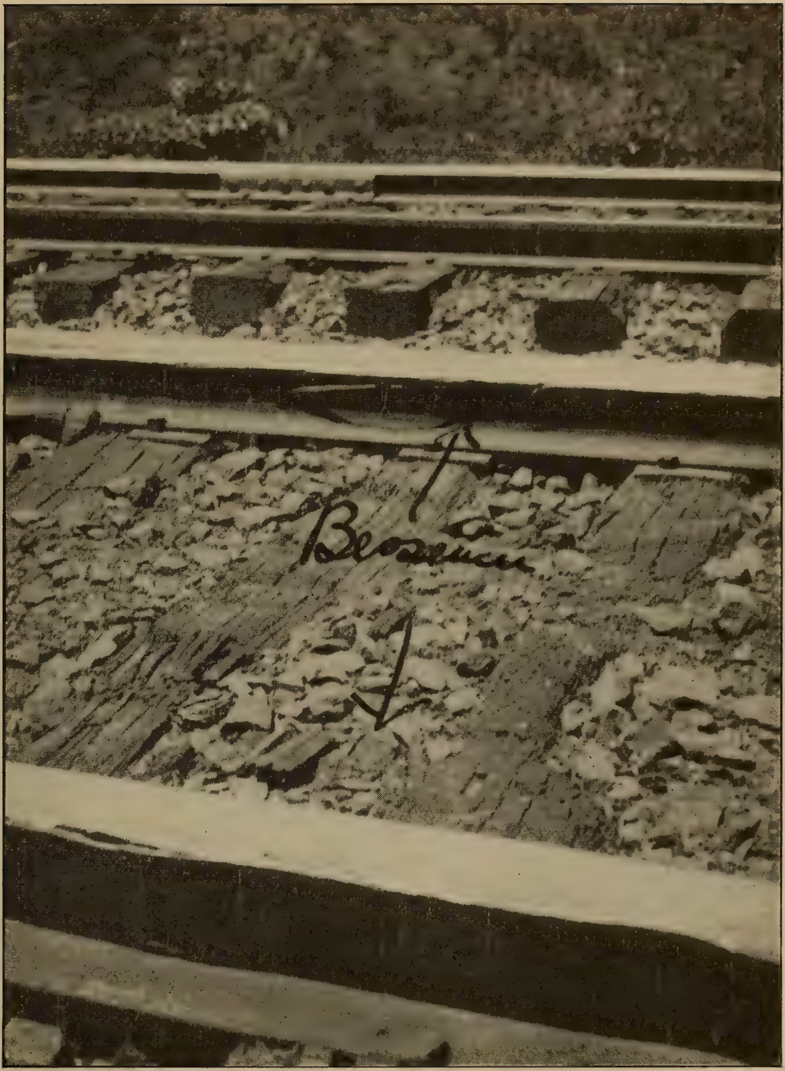
The mode of adding titanium alloy to the molten steel differs somewhat with the mode of manufacture of the steel itself. In general, the titanium is the last thing added. It is not the purpose that it should perform the whole duty of deoxidizing. This is more economically done with manganese and silicon alloys. The titanium performs the finishing work, eliminating impurities left behind by the other purifiers. If the steel is being made by the acid open-hearth process and the manganese and silicon are introduced while the molten metal is still in the furnace, the titanium alloy may be added during the process of charging the ladle. As soon as the steel is a foot or so deep the alloy will be added. It is of advantage to throw it into the commotion made by the inflowing stream of steel. It is thought to be well to have the ladle a little to one side of the stream, so that any alloy which



RESULT OF BENDING TEST ON TITANIUM RAILS comes to the surface may have an increased chance of being caught again, and again carried under. The object in view is to mingle the alloy with the steel thoroughly and quickly. In the manufacture of basic open-hearth steel where the silicon and a portion of the manganese may be introduced in the ladle it will be important to add the titanium very promptly after these. However, it is always to be added last. Further, the titanium alloy should not be preheated, but added cold. In the Bessemer process, in case the other reagents have been added while the steel is in the converter, the titanium is properly introduced into the stream of steel flowing into the ladle. Here, too, the ladle may set a little to one side to facilitate thorough and prompt mixing. In all cases the ladle should be held for a period of from three to ten minutes to permit the reactions to

LONG SHEAR BREAK, SHOWING TENACITY OF METAL, TITANIUM RAIL

LONG SHEAR BREAK, TITANIUM RAIL

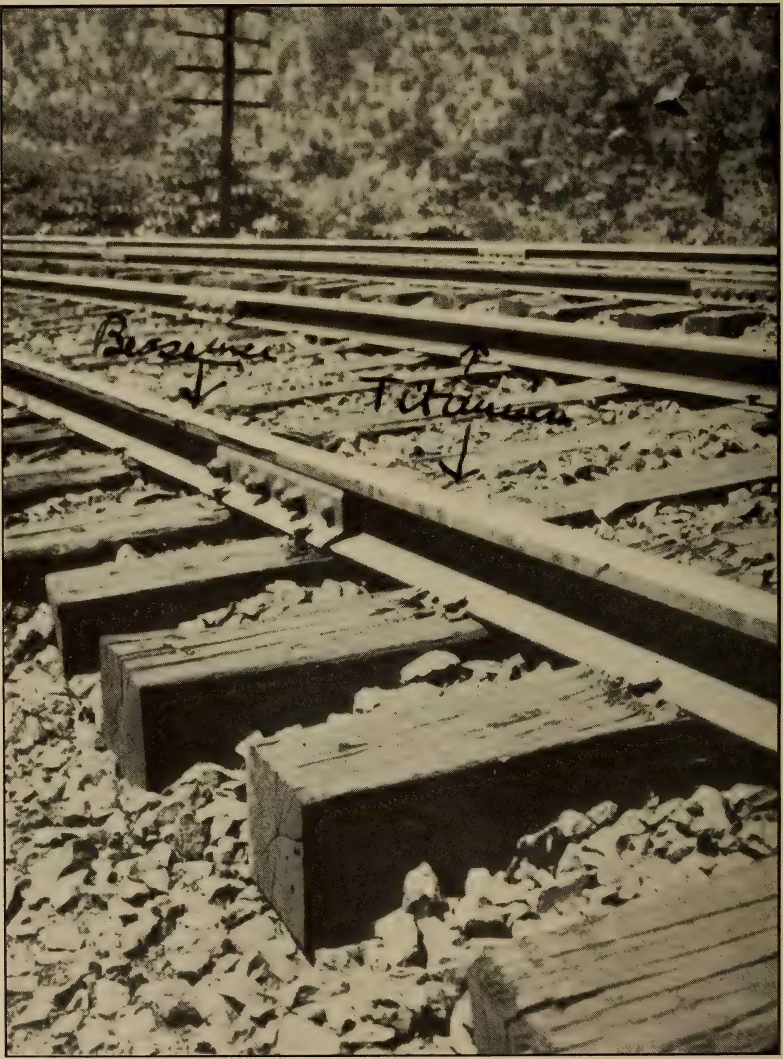


COMPARATIVE WEAR ON BESSEMER AND TITANIUM RAILS

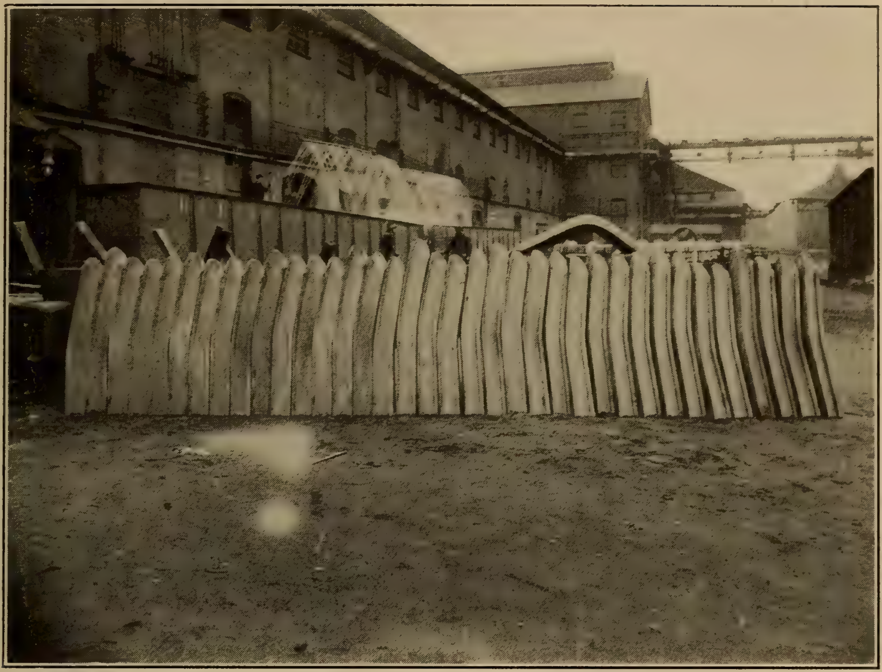
take place. The shorter periods are ordinarily sufficient for the Bessemer steel. In all steel the alloy is added cold—there is thus no pre-heating expense and no difficulty arising from the handling of hot material.

Perhaps the most interesting application of the titanium process has been in connection with railway rails. Mr. von Maltitz has the analysis of a number of cases of rail steel made subsequent to the rolling of the rails. From a certain heat three rails were investigated, each in three locations—upper left corner of the rail head and web, and bottom flange. This was repeated for a number of heats. Furthermore, the three rails from each heat came from the top, middle and bottom of the ingot. The highest average carbon content in three heats, as shown by analysis before me as I write, came from the middle of the ingot. The carbon range of this heat was from 0.50 to 0.60 per cent. In another heat the range was

0.54 to 0.58; in the third from 0.51 to 0.56. The entire range of the sulphur for the nine rails of the three heats varied from 0.037 to 0.065 per cent.; of the phosphorus, from 0.093 to 0.101 per cent.; of the manganese, from 0.810 to 0.900; and of the silicon, from 0.122 to 0.164. When we can see the results of the physical tests, we find that the elastic limit has been distinctly raised, probably by the titanium treatment. It is possible, too, that the ultimate strength has been increased, although here the improvement does not appear to be so marked. Six tests were made for each of the seven heats, two for each of the three rails coming from the top, centre and bottom of the ingot. If we regard 80,000 pounds per square inch for the elastic limit as a good value for an ordinary Bessemer rail of, say, 0.55 per cent. carbon, then we find that in no single

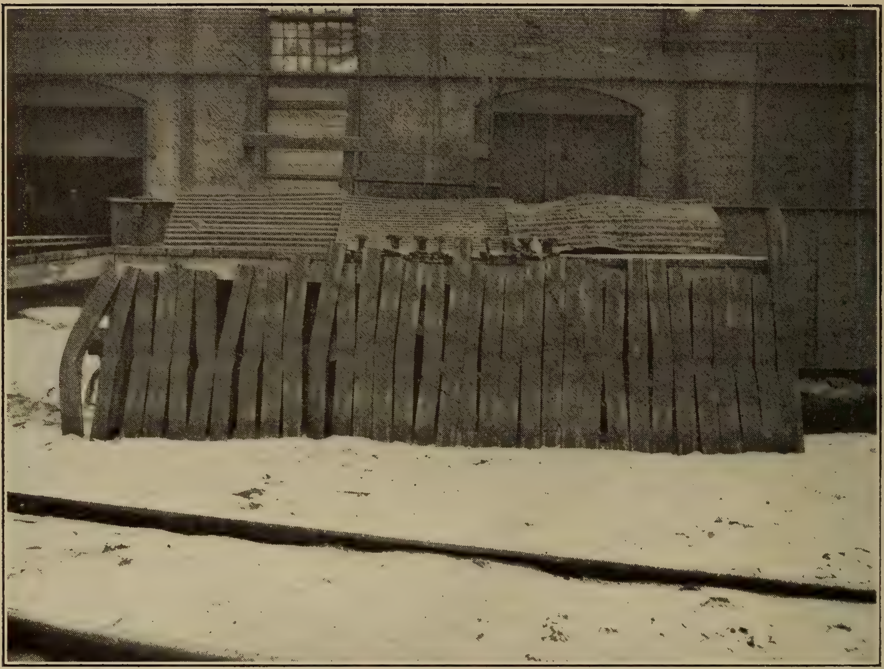


COMPARATIVE WEAR ON BESSEMER AND TITANIUM STEEL RAILS

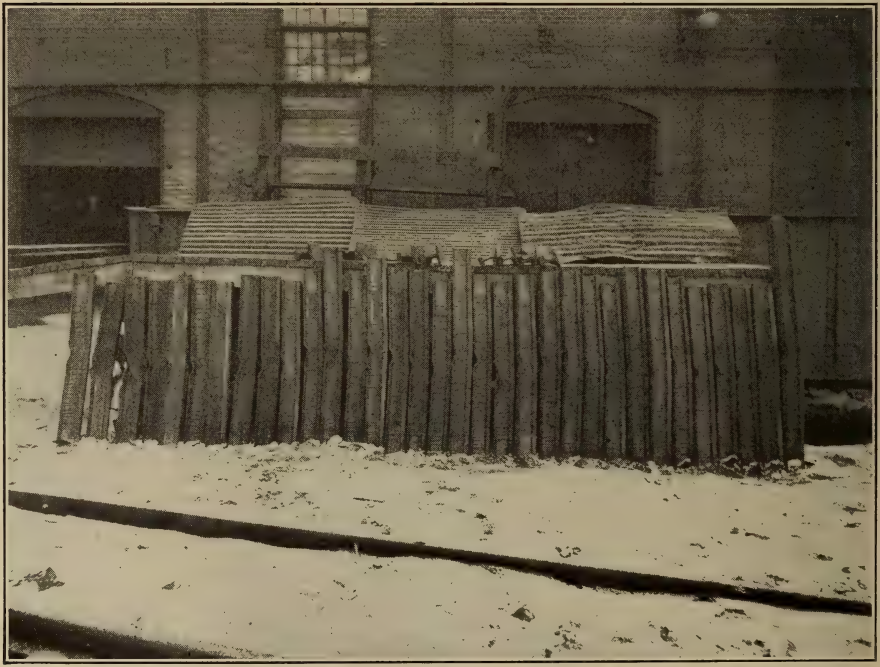


A NUMBER OF TITANIUM RAIL SECTIONS AFTER DROP TEST; TWO BLOWS ON HEAD

SEVEN-FOOT DROP TEST, TITANIUM RAILS



TITANIUM RAILS AFTER THE DROP TEST OF TWO BLOWS ON HEAD AND ONE ON BASE WITHOUT FRACTURE



SIDE VIEW OF TITANIUM RAILS AFTER THE DROP TEST OF TWO BLOWS ON HEAD AND ONE ON BASE WITHOUT FRACTURE

TEN-FOOT DROP TEST, TITANIUM RAILS

case but one of the forty-two was so low a figure reached. This exception had an elastic limit of 78,930 pounds. The remainder ranged from 82,920 to 95,010 pounds. The ultimate strength fell as low as, but no lower than, 108,900; and rose as high as 124,170 pounds.

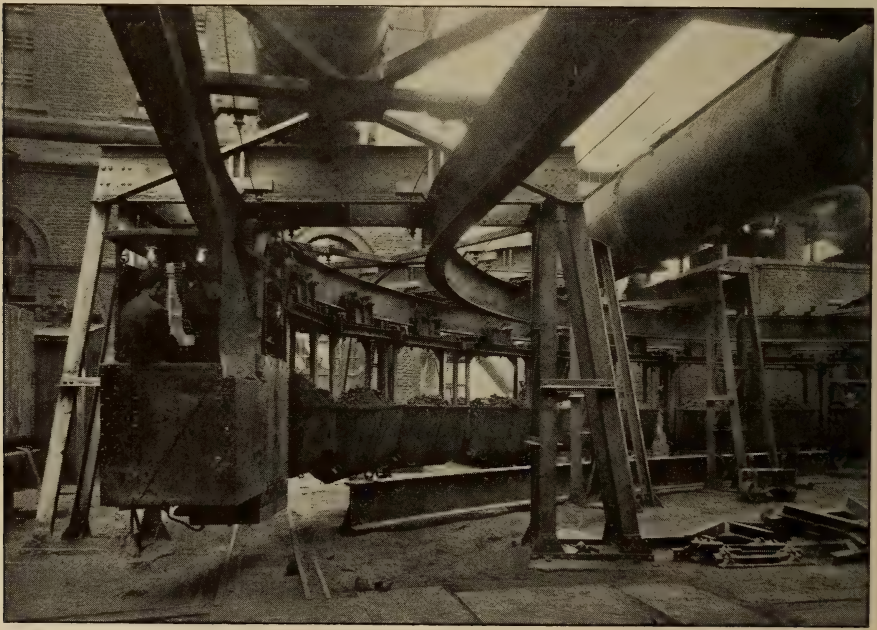
The elongation ran anywhere from 10 to 20 per cent.; and the reduction in area, from 9.8 to 28.6 per cent. In performing the drop test the weight, or trip, was 2,000 pounds, and the fall 17 feet. The tests were made upon pieces 3½ feet long with 3 feet between supports. These rails were of 85-pound per yard section. First three drops would be made upon the head, when the rail was turned upside down and the drops continued. Thirteen such tests were made, all seven heats being represented. The maximum amount of deflection after the first blow was 1.6 inches. After the second blow, the maximum deflection amounted to 3.5 inches. After the third blow, the greatest deflection was 4.4 inches. Upon reversal, one rail broke at the fourth drop from the beginning. Most of the rails were simply straightened. On the fifth drop, nearly all were broken altogether or on the flange.

I may now be permitted to cite some results of testing some medium carbon steel made by the basic open-hearth process. The chemical composition was C, 0.55; P, 0.026; S, 0.0290; Si, 0.155; Mn, 0.610. This metal was rolled down to wire rods, when the specimen was taken. The average diameter was 0.218 inches, to which a cross-sectional area of 0.0373 square inch corresponded. The elastic limit was found to be 91,000 pounds per square inch, and the ultimate tensile strength 114,400 pounds per square inch. The elongation amounted to 28 per cent.; and the reduction in area 52 per cent. After the titanium had been added the steel was held for ten minutes. The tensile strength is thought to have been increased about 20 per cent. This was accomplished at a cost of about 75 cents per ton.

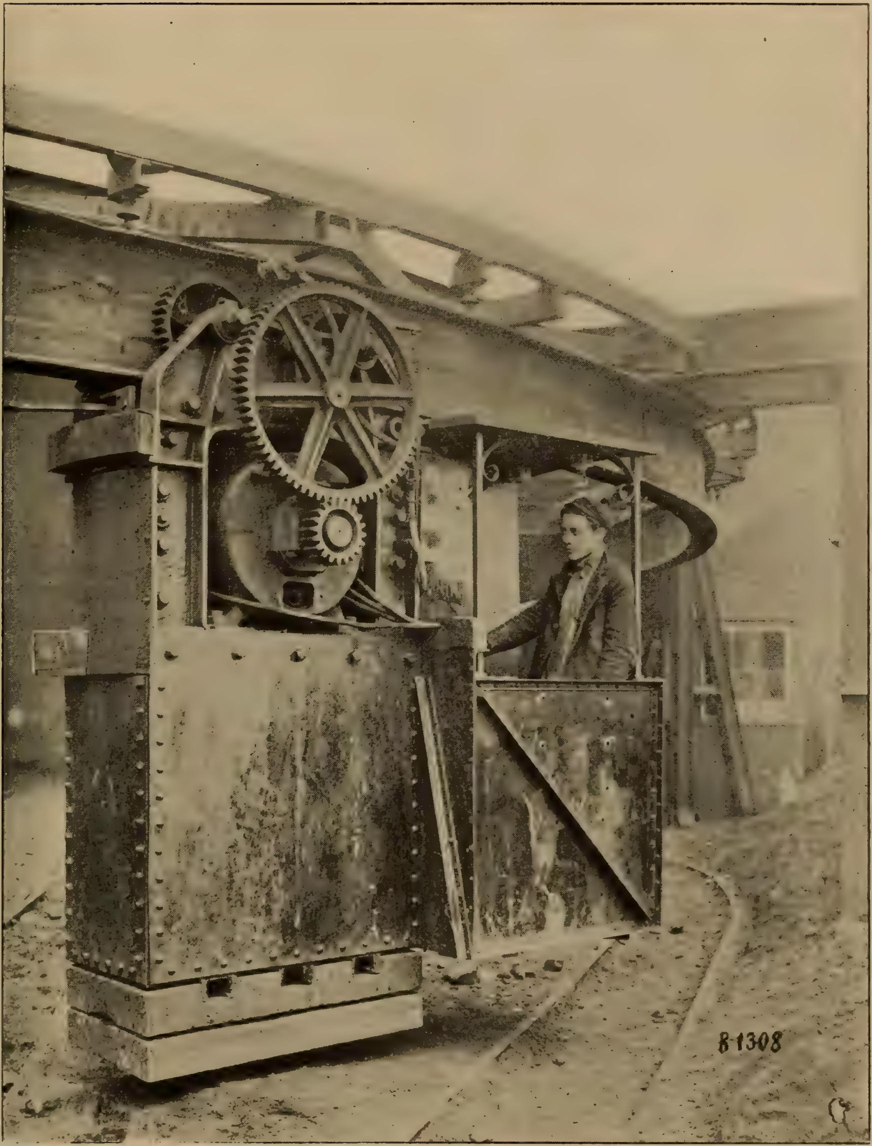
# SUSPENDED ELECTRIC RAILWAYS FOR INDUSTRIAL SERVICE

By J. F. Gairns

THE usefulness of works railway systems is now so generally realized that there is hardly an industrial establishment of any magnitude that is not equipped with a railway system of some kind for inter-department transportation; but in England the general rule is to employ surface tracks on which manually-propelled, or horse or locomotive-hauled, vehicles travel, whereas suspended railways, in which the vehicles are suspended from carriages which travel on rails supported overhead, are comparatively extensively employed elsewhere, though they are still somewhat exceptional in Great Britain. Yet there is a good deal to be said in favour of these suspended railway systems, either in conjunction with, or in place of, a surface system. On the score of expense there may be advantage, and in some cases the gain in this respect may be considerable; but probably the principal advantages are: (1) That the contour of the ground does not require consideration in laying out the system, except, of course, as regards varying heights of the overhead rail supports on uneven ground; (2) the ground surface is quite clear of rails or obstructions; (3) the suspended vehicles can be carried at such a height that there is no interference with traffic on ground level; (4) the vehicles can be adapted to travel over machines, hoppers, stoves, railway tracks, buildings, and even through openings high up in the walls of buildings, without interfering with operations below, and in a way that would be nearly



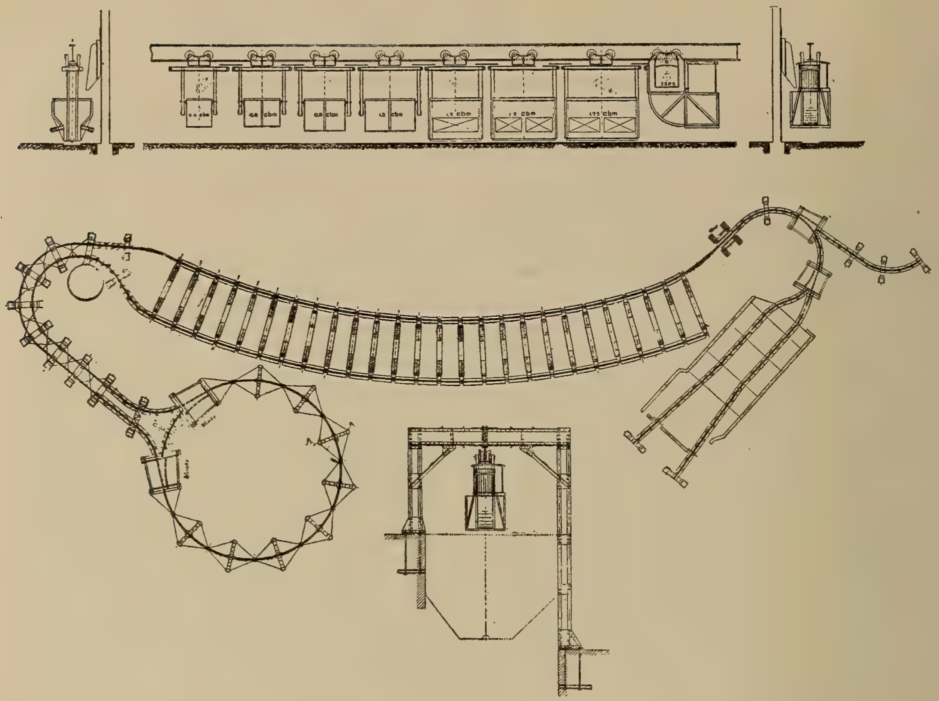
COMPLETE SUSPENDED TRAIN AT WORK



LOCOMOTIVE OF 25 HORSE-POWER USED ON OVERHEAD ELECTRIC RAILWAYS

impossible with an ordinary two-rail railway system; (5) the vehicles can be provided with raising and lowering gear, and with tipping and emptying mechanism, so that they need only be brought into the required position, raised or lowered to receive or deliver a load, or tipped or otherwise emptied into hoppers, store buildings, furnaces, kilns and the like from overhead; and (6) the tracks can be supported from buildings, constructural iron work, or special supports, and carried around buildings, machines, furnaces, and, in fact, wherever and however required, with severe curves and gradients to meet almost any requirements.

In practice any or all of these advantages may be realized, but, as a



OVERHEAD ELECTRIC RAILWAY AT THE DUGREE IRON WORKS. ARTHUR KOPPEL, BERLIN

rule, all of them are not provided for in one installation. For example, in many plants the suspended vehicles travel close to ground level, and therefore a clear passage has to be provided for them while passing, but even in that case there is no obstruction to surface operations except at the moment of passing, and there are no surface rails, while the ground may be so irregular or inclined that a surface railway would require a lot of preparation.

On a small scale such suspended railways may comprise little more than a light rail, or even a cable, carried on supports, the vehicles being suspended from small two-wheeled carriages running upon the rail, the weight distribution being such that the vehicles run in a practically balanced condition. The motive power may be provided by men walking upon the ground and pushing the vehicles, by means of gravity, by cable haulage, or by electric power supplied by a conductor rail or cable to small electric motors carried by and propelling the carriages which travel on the supporting rail. In some cases automatic or semi-automatic appliances are also provided, so that the vehicles travel by themselves, and can be directed as required without personal attendance.

On a larger scale the supporting rails are arranged upon girders, and the structure is of a substantial character, while the motor arrangements, frequently comprising a locomotive, in which a driver travels, necessarily corresponds more or less with that of surface railway equipments for dealing with fairly heavy work.

The equipment of such suspended railways is undertaken by various firms in this country, and there are several interesting installations in use; but the well-known German firm of Arthur Koppel makes a specialty of such work, and by the courtesy of their London manager we are able to describe a specially interesting installation recently carried out by them.

This system has been erected at a large Continental steel works and rolling mills for supplying ore to the furnaces. The particular requirements to be met are to provide for the loading of various qualities of ore from the ore bins and then conveyed as one train to the mixing hoppers; and for this purpose seven wagons of different capacities are adapted for use at a time, these being simultaneously loaded at the ore bins and conveyed by a locomotive to the mixing hoppers. The total load is 15 tons of various ores. The complete train is shown on the drawings reproduced, together with a plan of the tracks, and other views of the plant. The two photographic views show respectively a view of a complete train at work and the locomotive. The latter is of 25 horse-power and the main features of the design are well shown. The controlling equipment corresponds with ordinary tramway equipment. Current is collected by means of a small trolley pole, the roller of which runs on a light conductor arranged alongside the traveling rail. Some of the wagons are side tipping, and the larger ones are adapted for bottom discharge. The capacities vary from 20 to 63 cubic feet. The traveling rail consists of a rolled steel joist 20 inches high, supported on various structures, according to local circumstances. The average height of the bottom flange above ground level is 8 feet 4 inches, and the radius of the sharpest curve, in some cases more than a semicircle, is 23 feet. The overhead switches are somewhat similar to traverses, a rolling framework being employed, so that one rail section may be moved transversely or replaced by another one corresponding to the diverging route. These switch traversers are operated by chains and pulleys from ground level. Usually the load is pushed, and for that reason the locomotive and vehicles have wide arc-shaped bearing plates, by which the propelling force is transmitted from one vehicle to the next throughout the train.

# HUMAN ENERGY AS A MOTIVE POWER

By B. S. Greenfield

In considering the various attempts which are now being made to develop a high degree of efficiency in the use of human energy it is important to start right, and to determine whether it is desirable to employ animal muscle at all as a source of power for effecting work. It is beginning to be realized that the proper use to make of man's power is to employ it in the direction of sources of power in nature, and not as a source of power itself, and in this interesting paper Mr. Greenfield shows that even at its best, human energy does not compare in possible efficiency with mechanical power, showing that efficiency studies should be directed to the increased use of machines rather than toward greater physical activity on the part of the operatives.—The Editor.

ACCORDING to the calculations of a well-known scientist, the human body as a source of motive power is not only more efficient than any other engine, but will outlast five locomotives, keep in order three times as long as a printing press and twelve times as long as a motor car. For a given amount of fuel, the body, we are told, will do twice as much work as any other machine, and in this respect is unapproached.

That the human body is a wonderful mechanism, few will deny. Nor will anyone doubt its superiority over the complicated steam engine, the printing press, or other intricate device. And yet the fact is that, in spite of all its marvelous powers and good qualities, human labour has been and continues to be displaced by machinery, driven for the most part by energy artificially derived.

Without attempting to theorize as to why this is so, it becomes an interesting and useful problem to examine into the value of the human mechanism as a source of motive power. It is the object of this paper to investigate some of the characteristics of "man-power" and to compare these with those derived from other sources of energy.

Like all prime movers, the human body must be supplied with fuel if it is to be kept in good running order. Unlike the steam or gasoline engine, the animal mechanism has the marvelous capacity of not only performing external work, but also of making its own repairs at the expense of the food. It is a true saying that we not only eat to live but live to eat.

The object of food is not merely to supply the wastes of the organism. It must furnish also a surplus of energy for the performance of external work. Indeed, the modern physiologist has come to look upon the subject of food much as the engineer looks upon the subject of fuels.

### DEFINITIONS

A fuel is generally understood to be a substance which will unite chemically with oxygen, with the evolution of heat.

The amount of heat required to raise the temperature of 1 pound of water at 39.1 degrees F. through 1 degree F., is called a "British thermal unit."

The fuel value of foods, however, is usually expressed in terms of the kilogram, degree, centigrade unit, which is called a calorie. By a calorie, therefore, is meant the amount of heat which is required to raise the temperature of 1 kilogram of water (2.2 pounds) at its maximum density (4 degrees Cent.) through 1 degree Cent.

It has been found experimentally that the heat represented by one British thermal unit, if converted into mechanical work, would be equivalent to 778 foot-pounds. A foot-pound will here mean the amount of work done in raising a weight of 1 pound 1 foot high.

A calorie if transformed into mechanical work could raise nearly four times 778 pounds 1 foot high. More exactly, a calorie, if changed to motive energy, would be capable of lifting a weight of 3,063.6 pounds 1 foot high.

### ENERGY IN FOOD

According to Meinert, a man doing ordinary work requires daily an amount of food consisting of 50 grammes of fats, 100 grammes of proteins and 500 grammes of carbohydrates. It has been found, as a result of many experiments on nutrition, that the value of a food may, to some extent, be estimated from the percentage of protein it contains. Potatoes, rice, corn, butter and cow's milk may each be said to contain roughly 3 per cent. protein; while meat, fish, eggs and whole wheat may contain from four to seven times the above amount. It is generally held to be an established fact that man is better off on a low protein diet than on a high one.

Now, the total energy in the food which man consumes will depend on the nature and quantity of the stuff that is eaten. The table below, compiled from various sources, gives a rough idea of the foot-tons of energy in various kinds of commodities:

TABLE I.—FOOT-TONS OF ENERGY PER OUNCE OF FOOD

| | |
|---|---|
| 1. Cabbage | 16 |
| 2. Carrots | 20 |
| 3. Milk | 24 |
| 4. Beef | 27 |
| 5. Bread | 27 |
| 6. Ale | 30 |
| 7. Cheese | 36 |
| 8. Peas | 36 |
| 9. Potatoes | 38 |
| 10. Rice | 38 |
| 11. Corn | 38 |
| 12. Biscuit | 42 |
| 13. Oatmeal | 42 |
| 14. Sugar | 42 |
| 15. Porter | 42 |
| 16. Flour | 46 |
| 17. Bacon | 54 |
| 18. Cocoa | 69 |
| 19. Butter | 79 |

Table II shows the calculation of energy for a sample dietary. It will be seen from this table that our daily food would, on combustion, yield a quantity of heat represented by about 3,000 calories, or 9,000,000 foot-pounds. This is equivalent to the work done in raising a weight of 4,500 tons 1 foot high. One of the largest and most powerful locomotives in the world—an oil-burning type of engine on the Southern Pacific Railroad—weighs, with its tender, only 300 tons. Hence the energy of our daily food is about equal to that spent in raising thirty such engines 6 inches from the ground.

TABLE II.—SAMPLE DIETARY OF AUTHOR AFTER CHITTENDEN

| BREAKFAST. | Grammes. | Proteid, Grammes. | Calories. |
|---|---|---|---|
| 1 cup hot water | .. | ... | ... |
| 1 shredded wheat biscuit | 30 | 3.15 | 106 |
| 1 cup cream | 130 | 3.12 | 206 |
| 1 German roll | 57 | 5.07 | 165 |
| 2 1-in. cubes of butter | 38 | 0.38 | 284 |
| ¾ cup coffee | 100 | 0.26 | ... |
| ¼ cup cream | 30 | 0.78 | 51 |
| 1 lump sugar | 10 | ... | 38 |
| | | 12.76 | 850 |
| LUNCHEON | | | |
| 1 teacup chicken soup | 144 | 5.25 | 60 |
| 1 roll | 38 | 3.38 | 110 |
| 2 1-in. cubes butter | 38 | 0.38 | 284 |
| 1 slice lean bacon | 10 | 2.14 | 65 |
| 1 small baked potato, 2 oz. = | 60 | 1.53 | 55 |
| 1 rice croquet | 90 | 3.42 | 150 |
| 2 oz. maple syrup | 60 | ... | 166 |
| 2 lumps of sugar | 20 | ... | 76 |
| | | 16.10 | 966 |
| DINNER | | | |
| 2 rolls | 76 | 6.76 | 220 |
| 2 cubes of butter | 38 | 0.76 | 568 |
| 1 cup of cream of corn soup | 130 | 3.25 | 72 |
| 1 broiled lamb chop | 30 | 8.51 | 92 |
| ¾ cup coffee | 100 | 0.26 | ... |
| ¼ cup cream | 30 | 0.78 | 51 |
| | | 20.32 | 1,003 |
| Daily amount consumed | | 48.18 | 2.819 |

### ENERGY OF METABOLISM

The physical energy which we usually liberate at our daily tasks in shops and offices has been variously estimated. Nystrom* states that "a man working a crank" for eight hours per day spends about 50 foot-pounds of energy per second. That is, he exerts himself to the extent of 0.09 horse-power. According to the *Hutte*,† the energy expenditure in this case would be 8 kilogrammetres per second, or nearly 58 foot-pounds per second. The work per second of a man on a treadmill is, according to Nystrom, about ⅛ horse-power, and this is practically the same figure as is given by the *Hutte* (9.6 kilogrammetres per second). A man pushing or pulling in a horizontal direction is capable of 0.109 horse-power. A man raising his own weight up stairs or ladder for eight hours per day spends about 0.13 horse-power. The energy of manual labor at various kinds of work is shown in Table III.

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* Pocket Book of Mechanics (1877).

† Des Ingenieurs Taschenbuch; 19 Auflage (1905), S. 806 Abteilung 1.

In view of these results, we may take the average of man's daily work to be about 1/10 horse-power. This is equivalent to about 790 foot-tons per eight-hour day, or about 518 calories. Hein found that a man at ordinary work performs the equivalent of 65.3 calories per hour, or 522 calories per eight-hour day.[*] A. L. Gillespie gives the metabolism of a man at work as 217 calories per hour, and that of man at rest as 140 calories per hour. The heat equivalent of the work done is then 77 calories per hour, or 616 calories per eight-hour day.

TABLE III.—ENERGY OF MANUAL LABOUR

| Description of Work. | Hours Per Day. | Load, Pounds. | Velocity, Ft./ Sec. | Ft. Lbs. Per Sec. | Ft. Lbs. / Day. |
|---|---|---|---|---|---|
| 1. Carrying burden for 30 seconds only.... | .. | 252 | 0 | 0 | ...... |
| | .. | 126 | 11.7 | 1,474.2 | ...... |
| | .. | 0 | 23.1 | 0 | ...... |
| 2. Walking unloaded transport of own weight. | 10 | 140 | 5 | 700 | 25,200,000 |
| 3. Wheeling load in two wheelbarrows and returning unloaded ...................... | 10 | 224 | 1 2/3 | 373 | 13,428,000 |
| 4. One wheelbarrow, as above.............. | 10 | 132 | 1 2/3 | 220 | 7,920,000 |
| 5. Traveling with burden................... | 7 | 90 | 2½ | 225 | 5,670,000 |
| 6. Carrying burden and returning unloaded.. | 6 | 140 | 1 2/3 | 233 | 5,032,000 |
| 7. Raising his own weight up stairs or ladder. | 8 | 143 | 0.5 | 71.5 | 2,088,000 |
| 8. Pushing or pulling capstan or oar......... | 8 | 26.5 | 2 | 53 | 1,526,000 |
| 9. Turning a crank or winch................ | 8 | 18 | 2.5 | 45 | 1,296,000 |
| 10. Working pump ......................... | 10 | 13.2 | 2.5 | 33 | 1,188,000 |
| 11. Hauling up weight by rope and lowering rope unloaded ........................ | 6 | 40 | 0.75 | 30 | 648,000 |
| 12. Lifting weights by hand................. | 6 | 44 | 0.55 | 24 | 522,000 |
| 13. Carrying weight up stairs, returning unloaded ............................. | 6 | 143 | 0.13 | 18.5 | 400,000 |

We may assume the average of these heat equivalents to be 550 calories per eight-hour day.

But heat energy is lost from the body even when it performs no external work. An adult man asleep manufactures heat at the rate of about 40 calories per hour. Hein[†] found that a man gave off 283 calories of heat per hour while performing work equivalent to 65.3 calories. F. G. Benedict and Thorne M. Carpenter[‡] found that one subject driving a bicycle produced 3,959 — 1,340 = 2,619 calories of heat above the heat of resting metabolism while performing 569 calories.

THE TOTAL LOSS OF ENERGY IN MAN

If we assume the average heat loss of the body as 840 calories per eight-hour day and the average heat equivalent of the daily external work as 550 calories, then the average daily energy loss may be placed at 840 + 550 = 1,390 calories per eight-hour day. The heat production of a man working regularly may be as much as 1,750 calories per eight-hour day, while the heat production of a man at rest for the same period is about 1,100 calories. As to intellectual work, it is probable that mental effort has practically no effect on metabolism. Rübner has investigated the metabolism of men at various kinds of work, with the following results:

A fasting man produces 2,303 calories per 24 hours, or 767.6 calories per 8 hours.

A brain-worker produces 2,445 calories per 24 hours, or 801.16 calories per 8 hours.

A miner produces 4,790 calories per 24 hours, or 1,596.6 calories per 8 hours.

A lumberer produces 3,560 calories per 24 hours, or 1,786.6 calories per 8 hours.

More recently, calorimetric experiments at the United States Bureau of Agriculture[*] show that a ma-

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[*] The Natural History of Digestion, page 338.

[†] The Natural History of Digestion, page 339.

[‡] U. S. Dept. of Agriculture, Experiment Station Bulletin No. 208, page 36 *et seq.*

[*] Science, May 5, 1911.

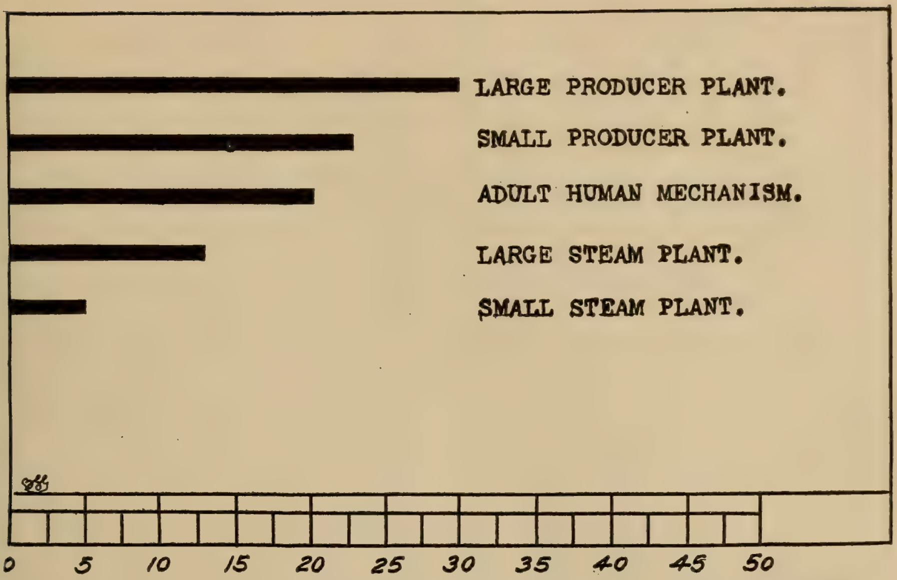

FIG. 1.—PER CENT. OF ENERGY FROM FUEL AVAILABLE FOR EXTERNAL WORK IN BRAKE HORSE-POWER

son or carpenter spends a total of 1,200 calories per day (presumably of eight hours' duration).

### EFFICIENCY OF THE HUMAN MECHANISM

If we observe that the average man's metabolism is more than that of a brain-worker and less than that of a miner, we may, for convenience and without great error, assign to it a value of 1,000 calories per eight-hour day. Assuming the energy in the food which man consumes daily to be about 3,000 calories, we find that the average daily output of energy is about one-third of the daily input. That is, the efficiency of the human body as an energy transformer is about 33 1/3 per cent.; and its fuel efficiency as a source of motive power is 550/3,000 = 18.5 per cent. Benedict and Carpenter tested the mechanical efficiency of a bicycle rider considered as a source of motive power with the following results:

Metabolism during rest = 92 calories per hour.
Metabolism of work = 619 calories per hour.
Heat lost above resting—
Metabolism = 527 calories per hour.
Heat equivalent of work = 112 calories per hour.
Mechanical efficiency = 112/527 × 100 = 21.3 per cent.

R. H. Thurston, in his "Animal Power," gives 20 per cent. as the thermo-dynamic efficiency of man. The eminent investigators Atwater and Benedict* have carefully measured the mechanical output of men driving an electric generator bicycle fashion, and found that the body was capable of transforming into muscular work 20.8 per cent. of the total energy liberated above that of resting metabolism.

It seems, then, that the body will ordinarily give out per day no more external work than about one-fifth of the energy consumed in the shape of food. The relative efficiency of animal and mechanical power is shown in Fig. 1. It will be seen that the adult human mechanism, while more efficient than a large steam plant, is less efficient than a small producer-gas plant, assuming all plants of the same capacity. This does not mean, however, that the body is incapable of working at greater efficiencies. Under extraordinary conditions the body is capable of performing an amount of work far in excess of the amount theoretically latent in the food consumed, as witness some of the remarkable results among our athletic records. It is even possible for the human mechanism to perform external work without taking food at all, the work so done being at the expense of the bodily tissue. This is the case especially in tests of endurance, where the extra energy is drawn from the animal cells.

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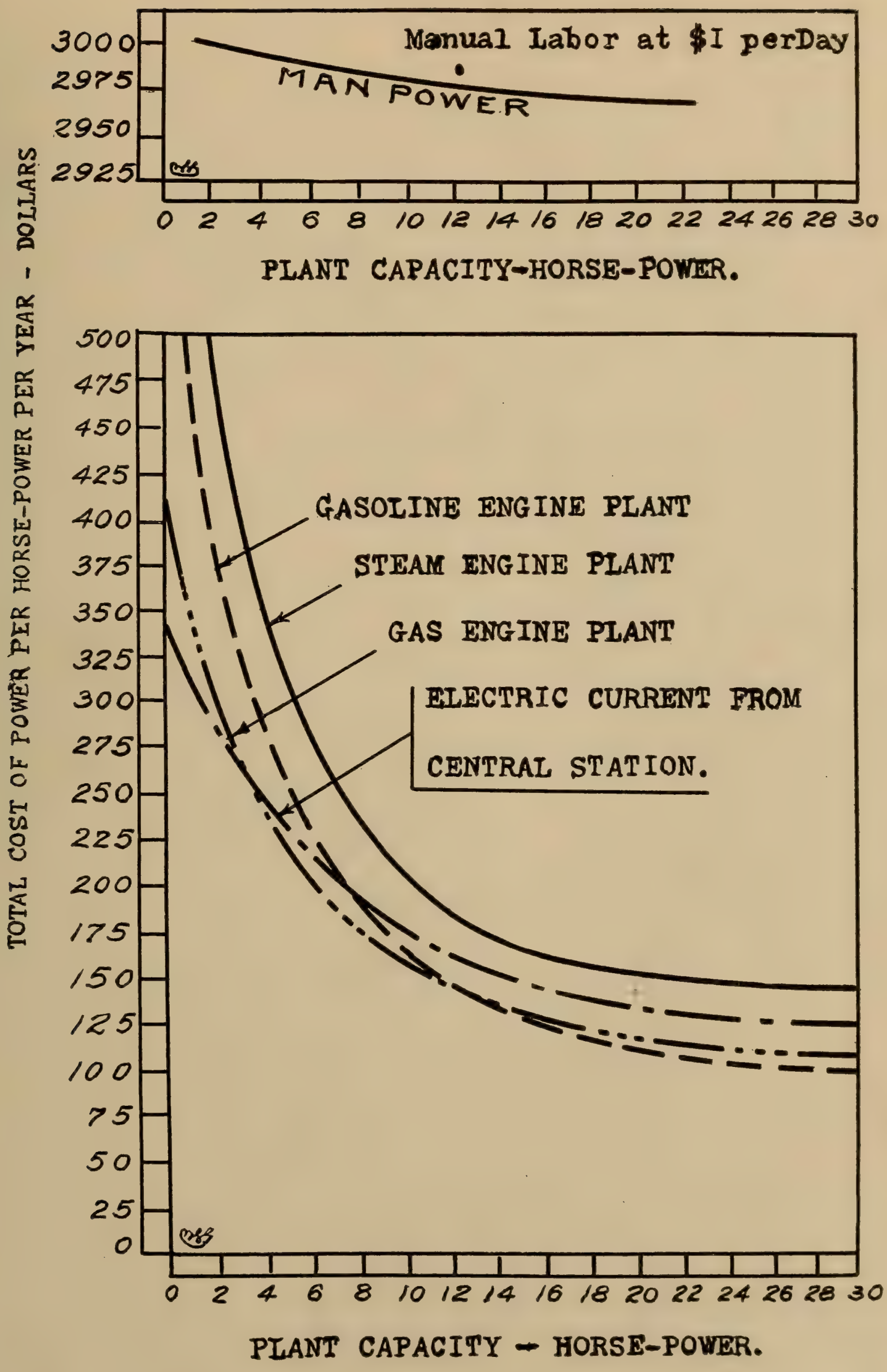
* U. S. Dept. of Agriculture; Experiment Bulletin 136, 1903.

### OBJECTIONS TO MAN-POWER

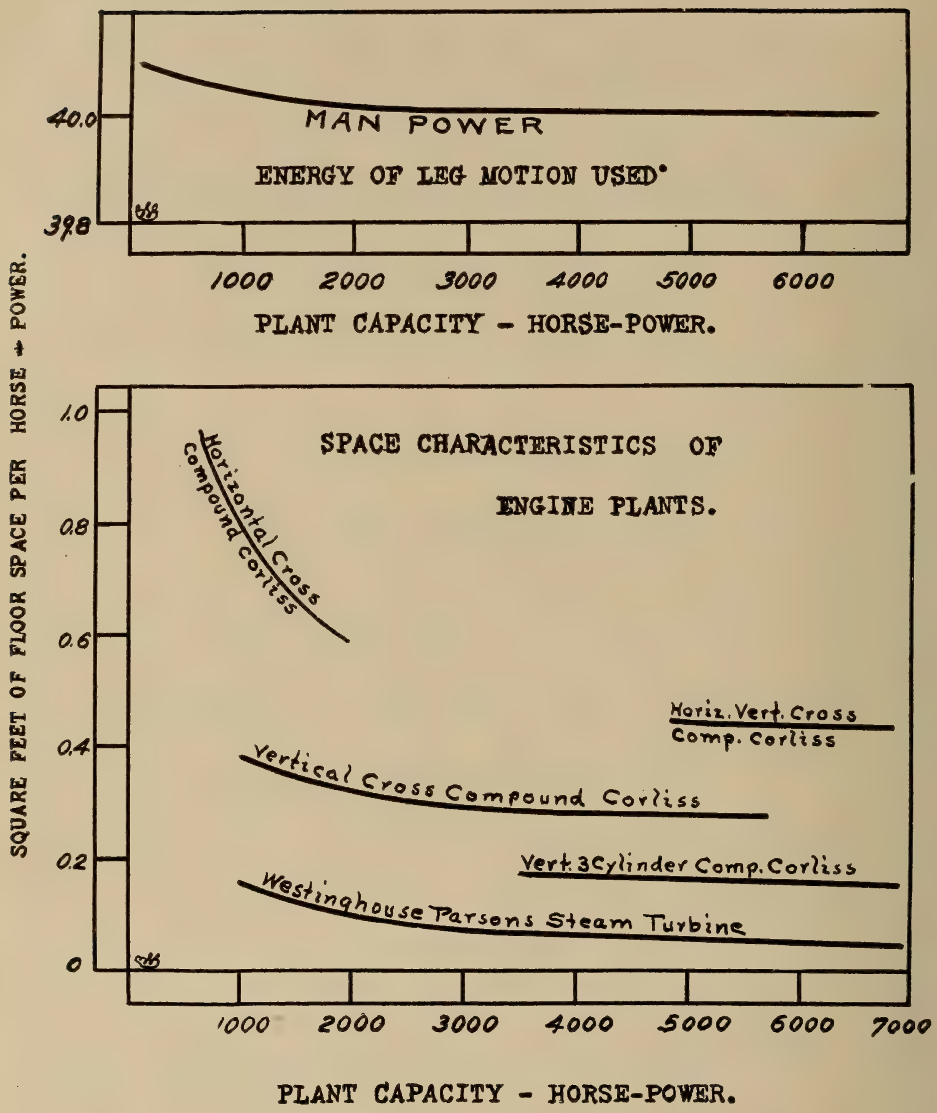
It stands to reason that the body cannot work long under these circumstances without a breakdown. Mr. P. E. Golden, of Long Island, ran 50 miles in 7½ hours, but no man could do so every day of the year. It is well known that the body cannot work under severe conditions without frequent intervals for recuperation, and this is one of the great limitations to the use of the human mechanism as a source of motive power.

Another serious objection to the use of "man-power" is the high cost of generating even small amounts of energy. If each man can produce, working ten hours per day, say, an average of 1/10 horse-power, ten men will be required to produce 1 horse-power. If labour be paid $1 per day of ten hours, the cost of 1 horse-power per day would be $10, and the cost of 1 horse-power per year would be $10 × 300 = $3,000 for the labour item alone. Aside from the cost of superintendence, rent of space occupied and other incidental expenses, this is at least 200 times the cost of generating power with modern plants of the more efficient types. Furthermore, it is not likely that the cost of man-energy per horse-power per annum would be greatly reduced by the employment of large numbers of men for bigger outputs. In this respect the animal mechanism is at a decided disadvantage over the mechanical plant, which can be built in a great variety of shapes and capacities, and which shows increasing economy per unit of power, with increase in capacity. In a general way it may be said that, with living motors, the cost per horse-power per annum is practically independent of the number of men used, while with mechanical plants the cost per horse-power per year decreases rapidly with the increase in plant capacity between fractional horse-powers and, say, 20 horse-power, after which the cost per horse-power annum remains practically constant. These relations are clearly shown in Figs. 2 and 3.

A third objection to the use of man-energy for motive purposes lies in the impracticability of securing large amounts of power from even very large groups of men. A little calculation will make this point clear: The power plant of a modern "department store" may contain, let us say, eight steam boilers with an aggregate capacity of some 4,800 horse-power. To produce 5,000 horse-power by the use of men it would be necessary to employ 5,000 × 10 = 50,000 men, who are supposed to drive the electric generators, tread-wheel fashion. Assigning a floor space of 2 feet by 4 feet to each man, these workers would require a total floor space of 50,000 x 8 = 400,000 square feet, which is about one-fifth of the total floor space in the Philadelphia store of John Wanamaker. Fifty thousand people would require a housing space equal to about thirty-three times the seating capacity of Madison Square Garden, one of the largest auditoriums in the City of New York. They would pack up four floors of a store like the one mentioned, in the generation of the energy required to operate its elevators, fans, refrigerating and other machinery. Add to this the space



FIGS. 2 AND 3.—RELATION OF ANNUAL COST PER HORSE-POWER TO CAPACITY OF PLANT, FOR VARIOUS METHODS OF GENERATING MOTIVE POWER



FIGS. 4 AND 5.—RELATION OF FLOOR SPACE PER HORSE-POWER TO CAPACITY OF PLANT, FOR GENERATING MOTIVE POWER

regularly occupied by electric generators, switchboards and other auxiliary apparatus, and the absurdity of using "man-power" becomes apparent. Where the energy of man's tread is utilized for the purpose of driving machinery the minimum floor space would probably be about 40 square feet per horse-power. The engine floor space at a "power station" in Boston using 5,000-kilowatt turbines is about 1.87 square feet per horse-power. The engine floor space of the Fifty-ninth street power station in New York, operating vertical engines, is about 0.8 square feet per horse-power. Taking the average floor space of engine plants in medium and large stations to be about 2 square feet per rated horse-power, we see that men as a source of motive power occupy at least twenty

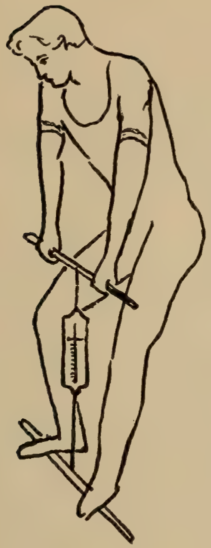


FIG. 6.—STRENGTH TEST OF THE BACK. 313 POUNDS

times the space of mechanical prime movers. The relation of plant space to plant capacity for various systems of generating power is shown in Figs. 4 and 5.

The futility of using manual labour for the generation of power to drive ships at sea is thus described by a writer in the *Engineering Magazine*:* "An ocean steamer of the *Lucania* class is propelled by a force of 30,000 horse-power. Counting six men to the horse-power and three shifts per twenty-four hours, the mere driving of the ship would call for 540,000 men; and if such a vessel could carry 10,000 men and their provisions, it would be only one-fifty-fourth of the size necessary to carry its own motive power." The entire population of New York, according to the same writer, could not do the work of a single 80,000 horse-power engine plant which is used to supply the elevated railroads of that city.

A fourth objection to the use of "man-power" is found in the consideration of the human mechanism as a vehicle of transportation, in which capacity it is represented in the "common laborer." If one wishes to get the most out of his exertion, the strength of the various groups of muscles should be tested and those which give the best results brought into the greatest play. A few general tests with a spring balance are shown in Figs. 6, 7, 8 and 9. It will be seen from Fig. 7 that the contractive force of the muscles which are used in walking are the largest of the four cases shown.

In both the act of ascending and of horizontal travel, man in walking operates at a greater efficiency than in any other form of exercise. That is to say, the human mechanism works at maximum efficiency when transporting the weight of the body only. And yet, even if every man were a Weston, we would still have our elevators, escalators, locomotives, steamships, trolley-cars, automobiles and aeroplanes.

As carriers of burden, the ox, the horse, the elephant and other animals have been used in preference to men. A horse in walking with burden will spend per day something like 35,000,000 foot-pounds of energy, or about seven times as much work as man can do, set at the same task. A horse, it is said, can bear on his back

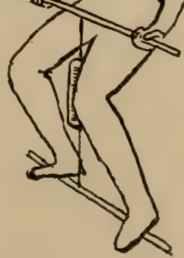


FIG. 7.—TEST OF STRENGTH IN LEG. 377 POUNDS

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* March, 1904.

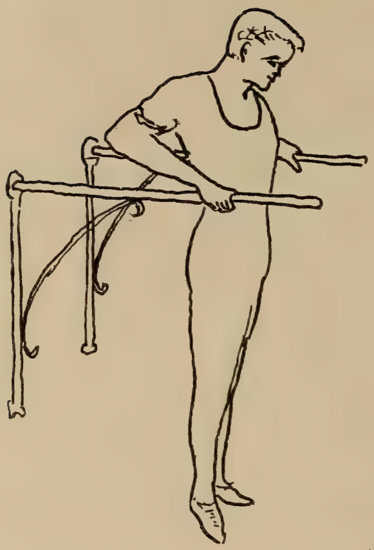

FIG. 8.—PUSH-UP TEST OF HUMAN ENERGY

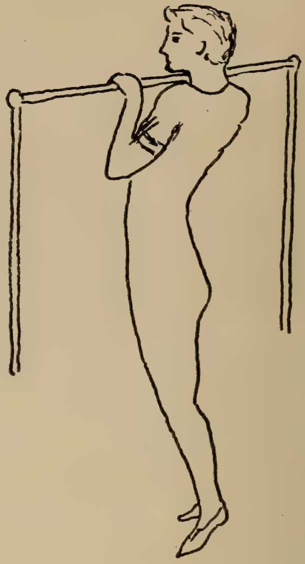

FIG. 9.—PULL-UP TEST OF STRENGTH

four times as much as can man and go twenty days without drinking, which can hardly be said of the most strenuous prohibitionist.

According to investigations made in New York,* the cost of transporting material in that city by means of a two-horse delivery wagon was in one case 10 cents per ton per mile; while the cost of delivering with a motor truck was only 4¼ cents per ton-mile—and the motor did the same amount of work in about two-thirds the time required by the horses. According to the data of a leading automobile manufacturer, the cost of operating a horse and buggy may be something like 2½ cents per passenger-mile, while the cost of operating a small gasoline car is only about 1¾ cents per passenger-mile. If horse-energy is so much more expensive than mechanical power, what can be said of "man-power"?

### CONCLUSION

It seems, then, in view of these considerations, that the exploitation of man for motive purposes cannot be thought of seriously. It may be true, as has often been asserted, that the human body is vastly more efficient than many man-made mechanisms, but it is evidently misleading to appraise the animal mechanism as a source of motive power on the basis of efficiency only. As to the use of any system of power generation, there is always the question: "Is it worth while?" A thing may be very efficient and yet not be adaptable to particular circumstances. Again, the cost of investment and of operation is an ever-disturbing factor which must be taken into account in the appraisal of any system for generating motive power. Furthermore, even if we are to make efficiency the sole criterion of operation, it appears that man was designed not for heavy physical exertion, but rather for intellectual activity. But, like all rules, this one, too, has its exceptions. In this age of specialization, particular men are adapted for particular purposes. The best disposition of individual talent is a matter for scientific study and research.

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* Transactions American Institute Electrical Engineers, Vol. 16, page 485.

# POWER TRANSMISSION IN GAS ENGINES

By Horace Allen

THE DEVELOPMENT OF TURNING EFFORT AT THE CRANK PIN BY THE POWER GENERATED IN THE CYLINDER OF A RECIPROCATING GAS ENGINE, AND THE POSSIBILITY OF IMPROVEMENT OVER MODERN PRACTICE

THE turning effort exerted on the crank pin constitutes the net available power which can be converted into work, and all other heat or power developed by the explosion of the gaseous fuel is waste, unless it is recovered as a by-product.

The crankshaft gives off turning effort only in proportion as it is communicated to it by the engine piston, and performs the work required, but in ordinary practice a considerable amount of power is lost by its being reconverted into heat.

A reciprocating piston cannot, by means of a rigid connecting rod, develop a constant value turning effort to a crank, because at the commencement and finish of the stroke the crank angle is nil.

Diagram Fig. 1 has been prepared to show the power curve which would be necessary to be developed in the cylinder to give the most equal turning effort possible in gas engines of ordinary construction.

Although the application of a heavy flywheel enables variations in turning effort to be equalized throughout the revolution, it does nothing to prevent the loss due to thrust on the bearings. On the explosion at constant volume principle the maximum pressure upon the piston is exerted while it is on the dead centre and becomes expanded as pure thrust upon the crankshaft, putting severe stress upon the shaft and engine frame. Any modification which will permit of the storage of the pressure at dead centre and its application at a later stage, when the crank angle becomes developed, would result in a reduction of thrust pressure and increase of turning effort, thereby converting a higher proportion of heat into effective work.

Retarding the ignition of the charge until the crank angle has developed somewhat is found in practice to result in a reduction of the mean effective pressure, but it has the effect of considerably reducing the thrust pressure, and, therefore, the tendency of the bearings of the crankshaft to heat.

This arrangement loses the benefit of the high expansion curve which results from explosion at constant volume and its accompanying economy. However, there are left to us two other means, which, though still encroaching upon the explosion at constant volume system, will restore at a more favourable instant the power to develop turning effort: (1) The application of a spring to the connecting rod, and (2) the adoption of an auxiliary piston in connection with the combustion chamber.

The application of a spring to the connecting rod has already formed the subject of a patent, but does not appear to have been commercially adopted. Further work in this direction, and the application of counter springs to reduce shocks may soon be within the range of practical application, but the strength of springs required to regulate the high pressure adds to the weight of the reciprocating parts and the inertia forces.

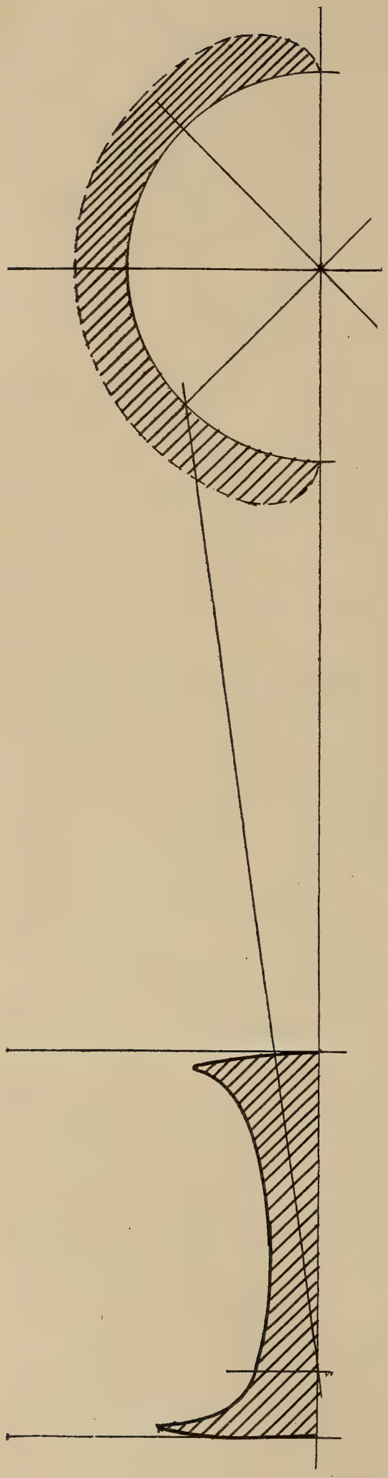


FIG. 1.—APPROXIMATE CURVE OF CYLINDER PRESSURES REQUIRED TO GIVE THE MOST EVEN TURNING MOMENT

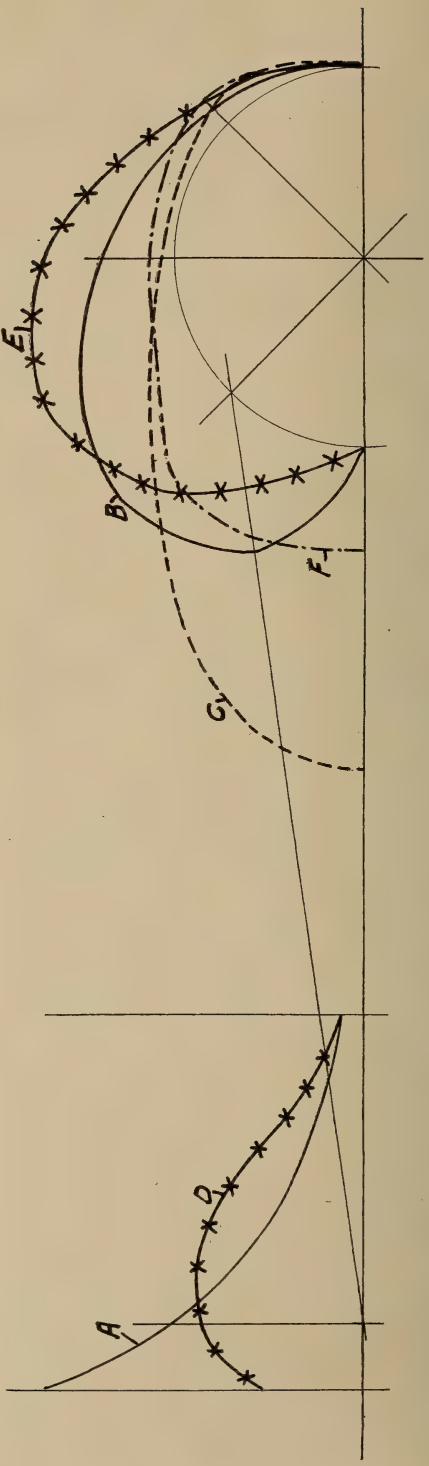


FIG. 2.—DIAGRAM SHOWING THE REDUCTION OF MAXIMUM PRESSURE AND THRUST AND INCREASE IN TURNING EFFORT

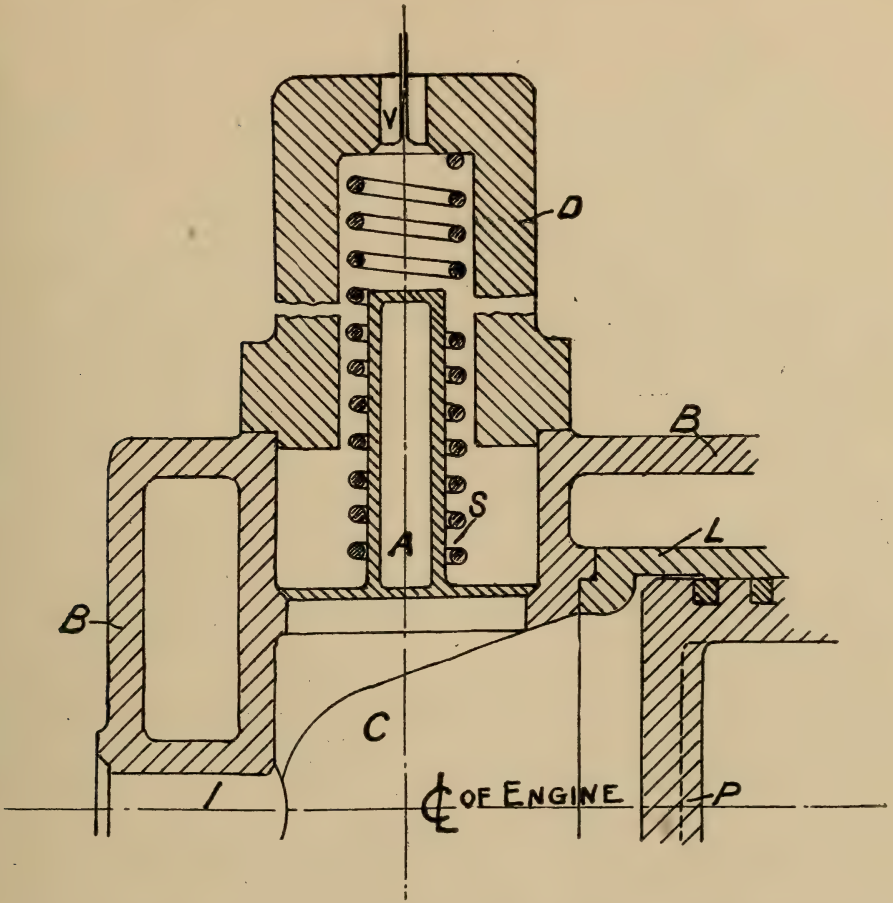


FIG. 3.—AUXILIARY PISTON REDUCING THE MAXIMUM PRESSURE AND THRUST AND INCREASING THE TURNING EFFORT

Diagram Fig. 2 shows the effect of a spring fitted connecting rod, or an auxiliary piston, in reducing the thrust and increasing the turning effort.

The pressure curve, as usually developed in a four-cycle single-acting cylinder of an internal-combustion engine fitted with a rigid connecting rod, *A* develops the turning pressure curve *B,* but the expenditure of pressure, as shown by curve *C,* is excessive at the point of ignition. By the introduction of either a spring connecting rod, or other means of storing the high-power peak at the point of maximum explosive pressure, the pressure curve in the cylinder would be somewhat as shown at *D,* and the development of turning pressure would follow the curve *E,* while the thrust pressure would at the same time be approximately that shown by the curve *F,* or less than one-third of that occurring in ordinary modern gas engines.

In this diagram the modifying effect of the inertia due to the weight of the reciprocating piston and connecting rod have not been allowed for, and this would show in increasing the curve of turning effort.

The very notable reduction of the maximum explosive pressure, and, therefore, the thrust on the bearings, crank and connecting rod, would allow of these parts being made proportionally lighter, and the reduced pressure would lessen the tendency to heating and therefore the quantity of lubricating oil required.

In Fig. 3 is shown a proposed arrangement for converting the thrust effort into turning effect by the application of an auxiliary piston to the combustion chamber of a common type of Otto cycle gas engine. The diagram shows the combustion chamber *C* of an engine in which the exhaust valve is inserted and withdrawn, through a port arranged immediately above it.

In place of the usual cover block a modification of the cover is adapted to allow of a floating piston *A* being inserted, which is in direct communication with the combustion chamber *C*.

Obviously the details of the auxiliary piston will be controlled by various circumstances, and according to whether or no a spring is to be employed.

In the illustration a spring is shown, *S*, the strength being sufficient to keep the piston *A* above the compression pressure, in which case the clearance space is not interfered with and the compression pressure remains as before.

When the charge is exploded the piston *P* is on the dead centre and can exert no turning effort, but a part of the maximum pressure is absorbed temporarily in lifting the auxiliary piston *A*, not only against the spring *S*, but also in compressing the air in the closed chamber formed at the back of the piston.

The main piston *P* would therefore advance under a pressure less than the usual maximum, but as soon as the connecting rod angle begins to have turning effect the air compressed by the auxiliary piston would expand and, with the spring pressure, increase the working pressure at a time when it is most advantageous, until such time as the cylinder pressure falls below the pressure the spring is proportioned to give, at which period the auxiliary piston would be seated.

The valve *V* is simply an automatic spring-carried valve for allowing air to enter the floating piston chamber, at atmospheric pressure, to make up for any leakage of air which may occur. The air space above the floating piston should be proportioned to the maximum explosive pressure, so that silent cushioning is obtained.

The diagrams indicate that any practical application of the proposed methods should be followed by improved mechanical efficiency, as well as economy.

# THE GYRO-COMPASS

By **A. C. Fredericks**

THE ancient magnetic compass, whose usefulness has never been questioned before in all these centuries of navigation and geographical discovery, seems destined to be supplanted by a new invention termed the gyro-compass.

For more than fifty years the gyroscope has enjoyed an enviable popularity among children as an interesting top, and among savants as a means for experimentally elucidating certain difficult theories in dynamics, but its practical uses have been recognized only in the last decade.

This extraordinary instrument, so simple in its physical aspects and so complex in its theoretical phases, was investigated scientifically by Foucault, the celebrated French physicist, in 1852. His gyros, like the tops of the present day, were rotated by means of a string, and, consequently, the speed developed was slow and the time of running was short.

In its simplest form the gyro consists of a heavy metal wheel, perfectly balanced and attached to a spindle. The ends of the latter are pivoted in a rigid ring, so that the axis of the wheel is free to turn in any direction and to be acted upon by two combined forces, one of which is gravity. When set in motion, the wheel tends to keep the axis of rotation always pointing in the same direction. With this crude device Foucault was enabled to formulate laws which showed his great powers of analysis and the practical value of which has been recognized only in the past few years. He discovered that if a gyro is held by its ring and is moved about, the revolving element will continue to rotate with its plane fixed in space, provided no physical means are employed to change the axis of rotation, and, further, that any motion whatever which tends to alter the direction of that plane meets with extraordinary resistance.

He next formulated a law to the effect that a gyro which is free to move in three planes will continue to revolve with its plane of rotation fixed in space while the earth turns round under it. Another law which he determined states that any gyro free to move in two planes only, will, at any place on the earth's surface, other than at the two poles, tend to set itself with its axis of rotation parallel to the axis of the earth itself, by reason of the relative rotations of the two bodies.

With these principles of the gyro in mind, it may be seen that as a compass for the navigator its application would appear to be comparatively easy. Apparently there were gigantic obstacles in the way of its practical realization. One of the chief difficulties is due to the fact that the centre of gravity and the centre of suspension of a gyro must be absolutely coincident.

With the increased use of steel in the construction of ships and the growing importance of the submarine boat, the need of some non-magnetic device for determining direction became a paramount issue and experiments were begun to find some such means.

Dr. H. Anschütz-Kampfe attacked the problem in 1900 and constructed a gyro having three degrees of freedom, and although this early form of gyro-compass was not suitable to take the place of the magnetic compass,

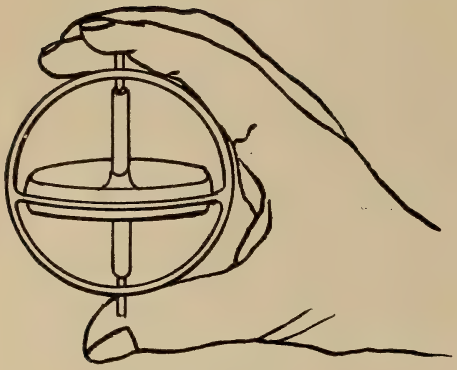


FIG. 1.—GYRO TOP

yet it was of considerable service in furnishing definite fixed lines in space, whereby bearings could be compared.

Although the gyro-compass having three degrees of freedom gave much promise, Dr. Anschütz found that further development along this line would result in a very complicated device, if perfected, and he therefore decided that a gyro with only two degrees of freedom would better satisfy the conditions required by a reliable compass.

Now, a gyro with only two degrees of freedom also had its disadvantages, since any external force, such as the rolling of a ship, would affect it as well as the force of the earth revolving under it. Naturally such outward forces cause the gyro to swing to and fro, or oscillate, and this, in turn, impairs its accuracy as a compass. To overcome these difficulties the inventor made the gyro wheel heavy, gave it high speed, and reduced the friction of the suspension system to a minimum; these factors increased its gyroscopic resistance to such an extent that it required considerable force to tilt its axle to an angle.

On the other hand, if a gyro was deflected the amplitude of oscillation would be greater and the period longer. The next step was to damp out the oscillations, and a second gyro was coupled to the first in an attempt to do this. Again complications arose, and the second gyro gave way to a pneumatic damping device, which is now an integral part of the gyro-compass.

To understand the theory upon which the gyro-compass operates, a simple explanation of the principles of precessional motion is necessary. That a gyro will persist in keeping its axle in the same direction is well known. Thus, if an ordinary gyro-top is held rigidly in the hand (Fig. 1) and the wheel is set in motion it will be found very difficult to hold it against the opposing forces which tend to move the axle at right angles to the force used to turn it, and this is called precessional motion. It will also be observed that if the axis of the gyro is moved in alignment to itself there will be no resistance offered by the gyro.

If the ring of a gyro is suspended by a cord and the wheel is revolved toward the right-hand end of the axis, the whole gyro will turn toward the right; and if an effort is made to depress the right-hand end of the axis the gyro will turn toward the left, this being, in this case, the direction of precession.

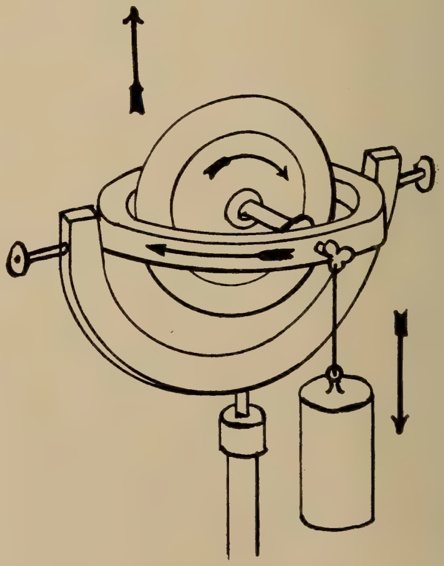


FIG. 2.—COMPOUND GYRO, WITH WEIGHT TO SHOW PRECESSION

In a compound gyro (Fig. 2), one capable of moving in three directions, the duration of precession causes the inner ring to revolve at right angles to the turning force, when this is offered at the pivots of the outer ring. All through the consideration of the action of the gyro-compass it must be remembered that precession continues all the time that force is applied to tilt the axle, and ceases as soon as the force no longer acts.

Having the idea of precession in mind, the reasons for the existence of a directive force must be explained. First of all, Foucault's theory contains the general statement that "every free rotating body, when subjected to some other or new turning force, tends to set its axis of rotation parallel to the new axis of rotation by the shortest path, so that the two rotations take place in the same direction." It is this principle which governs the practical working of the gyro compass.

The reason one end of the axle of the gyro always turns toward the north is that when the gyro (Fig. 3) is at position *A* the axle is horizontal and stands east and west. If after a certain interval of time the earth has rotated until the gyro is at the position $A_1$ then, in the case of a gyro with three degrees of freedom, namely, uniformly suspended and free to turn in all directions, the axis would no longer be horizontal as regards the surface of the earth, but the condition would be as shown in the figure $A_1$, the gyro having kept its axle parallel to the original position which it occupied at *A*, or in other words, the dark end of the axle would have dipped downward from the horizontal position.

In the gyro-compass it should be understood that the gyro itself is carried upon a float free to move in a bowl of mercury, so designed that as long as the gyro is not rotating the whole system is free to swing in any direction, like a pendulum. The centre of gravity of the whole moving system is below the metacentre. The gyro is mounted at the lowest point of the moving system with its axle horizontal, and it would therefore swing back to this horizontal position if disturbed and then left to itself; that is to say, while the gyro is not rotating the force of gravity always keeps the axle of the gyro horizontal, and, therefore, the float and compass card, which are rigidly connected, to take a corresponding position.

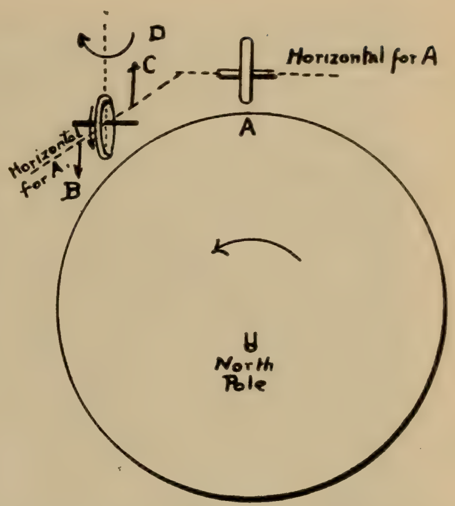


FIG. 3.—DIAGRAM SHOWING REASON FOR ONE END OF AXLE ALWAYS TURNING NORTH

As explained above, the gyro-compass is acted upon by the force of gravity, which tends to keep the axle horizontal; and this action may be described as a couple represented by the two straight arrows, *B* and *C*; under the influence of this the gyro precesses in the direction of the curved arrow *D*, the effect produced being exactly similar to that obtained by depressing one end of the gyro top, as previously described.

The direction of this precession will continue in the same course until a condition is arrived at when the action of gravity has no further effect on the suspended system; which is clearly so when the axle of the gyro is again horizontal. This occurs in the following manner: In Fig. 3 the rotation of the earth causes the dark end to dip downward; when,

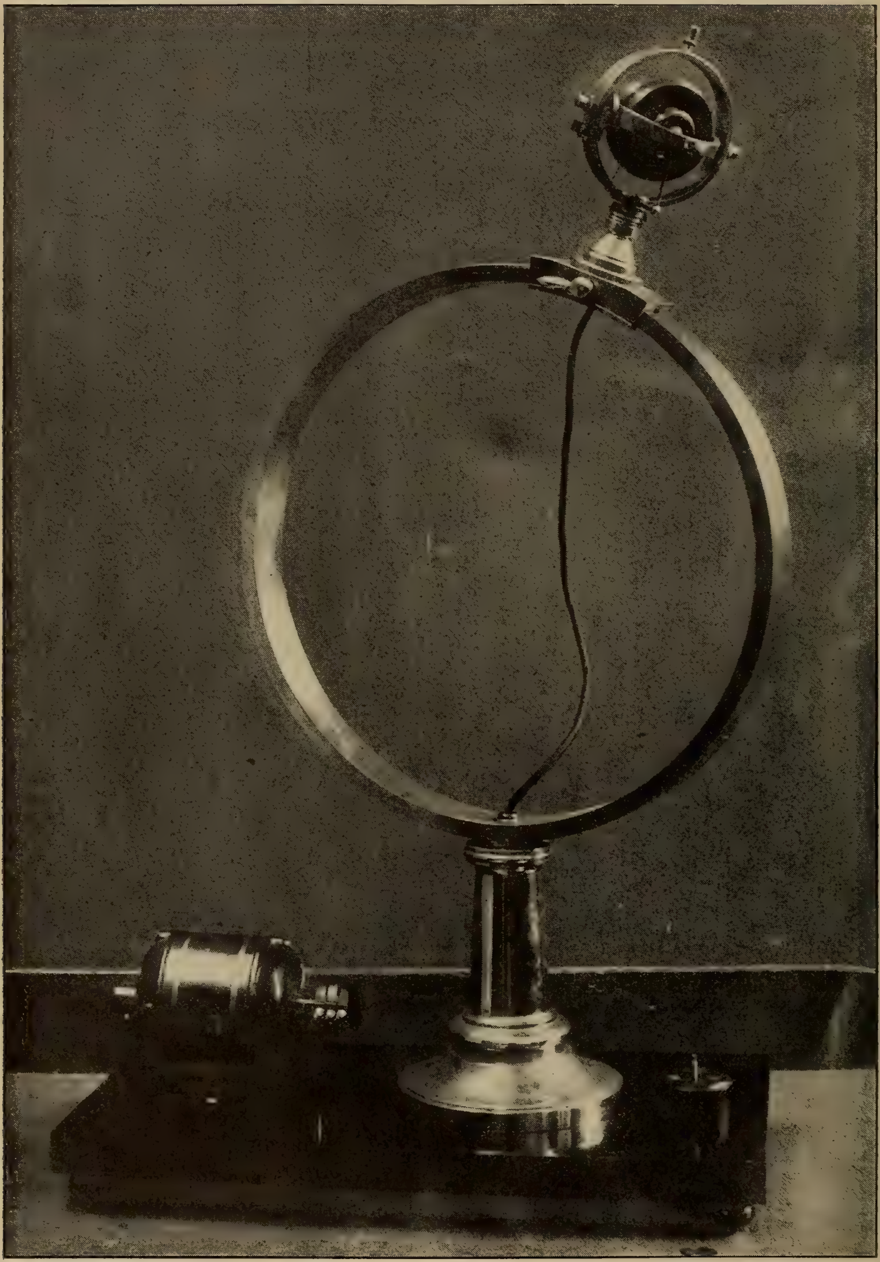


FIG. 4.—DEMONSTRATION MODEL TO ILLUSTRATE DIRECTIVE FORCE

however, the axle swings through the meridian it will be seen that the earth's rotation causes the dark end to begin to rise, and thus the axle becomes eventually again horizontal at the same angle from the meridian on the new side as it started originally on the old side, viz., 90 degrees.

When the axle is horizontal the precession, or oscillation to and from the meridian, comes to an end, and in all cases where this occurs (except when the axle is horizontal in the meridian plane) the action of gravity begins to tilt the axle of the gyro in the reverse direction of precession, causing the moving system to swing back toward the meridian again. Should the axis of rotation of the gyro not commence by standing parallel with the equator in the starting position *A*, a little consideration will show that, no matter in what position the gyro happens to stand, except due north and south, the earth's rotation will cause a precession toward the meridian, one end of the gyro always turning north and the other south, according to precessional law.

The directive force, which the rotation of the earth exercises on the gyro, diminishes as the poles are approached, because the higher the latitude the smaller the actual distance moved by the gyro in space in a given time. At the poles no directive force exists; there the horizontal plane is not subjected to any angular tilting and therefore there is no tendency for the axis of rotation of the gyro to be tilted by the action of the earth's rotation. Likewise at the poles no difference of compass direction exists, since every line is a meridian. Fig. 4 shows a demonstrative model illustrating directive force.

As soon as it is understood that the axis of rotation of a revolving gyro, when correctly suspended, possesses a directive force, due to the earth's rotation, in some respects analogous to the magnetic needle, the various points in the diagram can easily be followed.

Fig. 5 is a vertical section through the centre of the gyro- compass, as constructed for use on board ship.

The case *B* carrying the bearings of the gyro *A* is supported by means of a stalk below the float *S*, which consists of a hollow steel ring attached to a dome-shaped upper part. This floats in the circular bowl *K*, also made of steel and filled with mercury *Q*. Rigidly attached to the

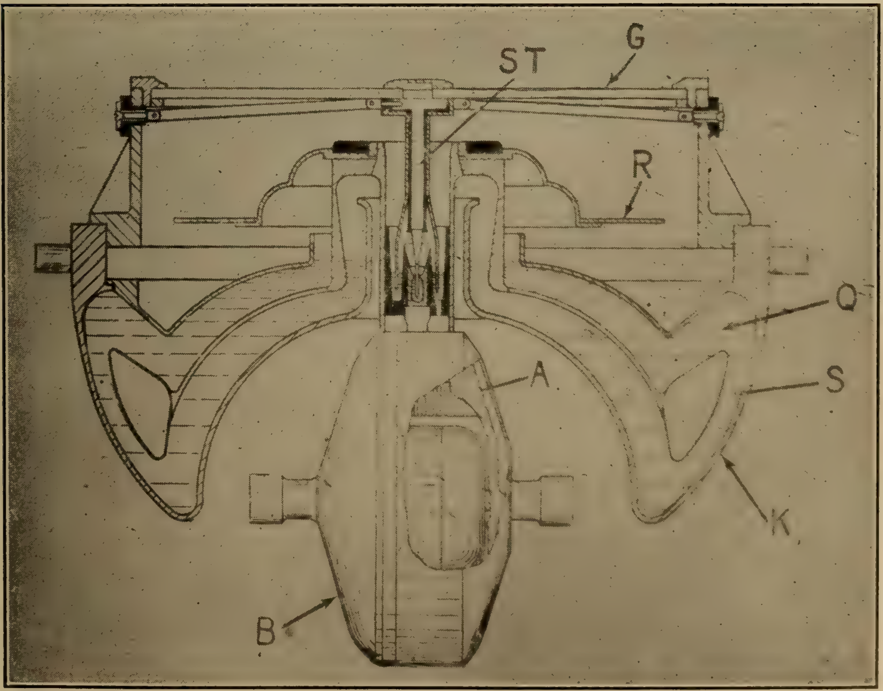


FIG. 5.—DIAGRAM OF VERTICAL SECTION THROUGH THE CENTER OF A GYRO-COMPASS

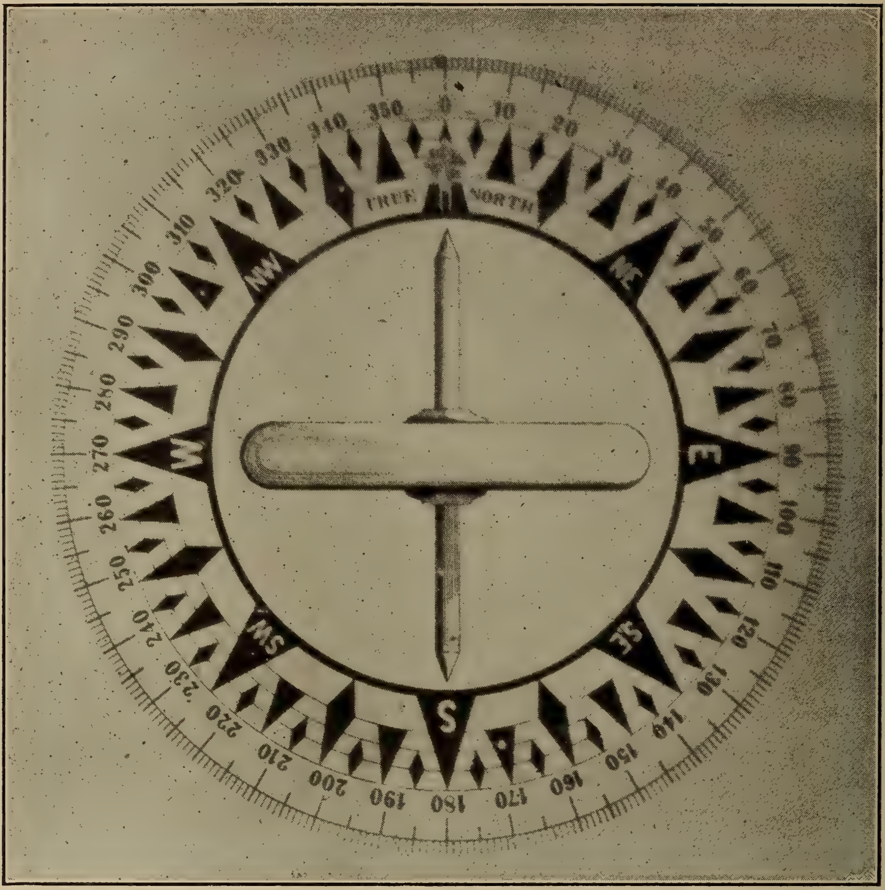


FIG. 6.—COMPASS CARD USED TO FOLLOW MOVEMENTS OF FLOAT AND GYRO ON BOARD A SHIP

float *S* and gyro *A* is the compass card *R*, which therefore follows all the movements of the float and gyro; the axle of the gyro is directly under the north and south line of the card, as is shown in Fig. 6.

Through the glass *G* or top of the instrument the division around the compass card *R* can be seen, and also the lubber line; a small spirit level mounted on the card makes it possible for any tilting of the axis of rotation of the gyro from the horizontal to be observed.

The whole mercury bowl *K* is carried on gimbals in the well-known manner, and the outer gimbal ring is held in place by springs from the binnacle case, so that it is to a great extent protected from damage due to violent shocks. As far as the gimbals and methods of suspension are concerned these do not differ materially from those of the ordinary magnetic compass.

In order to keep the whole floating system central, the steel stem *S T* is fixed centrally in the top of the glass *G*, and the lower end of the stem dips into a small mercury cup carried on top of the float. A similar connection is affected by a steel tube mounted concentrically with the stem *S T* and a second mercury cup. These two sets of connection are electrically insulated from each other and from the general portion of the apparatus.

These two connections carry two phases of a three-phase current to the

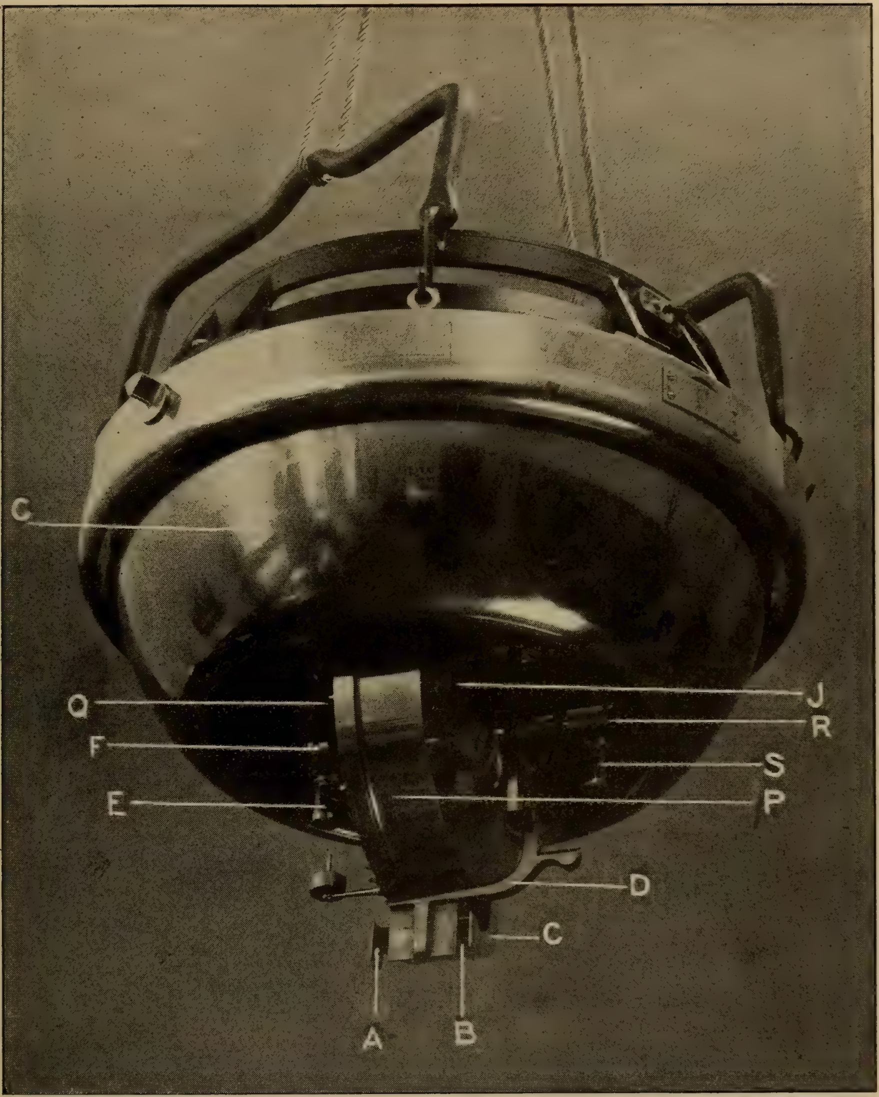


FIG. 7.—PNEUMATIC APPARATUS FOR DAMPING OSCILLATIONS

motor of the gyro; the third phase reaches the motor through the mercury bowl, mercury and float. For this reason the whole instrument is insulated from the binnacle.

The motor of the gyro is not shown in the diagram, but consists of a very small three-phase motor, the stator of which carries the windings, and is mounted inside the case *B*, so that all the connection can be rigidly fixed into the inside of the gyro flywheel itself.

The speed of rotation of the gyro is about 20,000 revolutions per minute. It is constructed, spindle and all, from one solid piece of special nickel steel, so that there is no chance for anything to work loose. To reduce the friction to a minimum the axle is provided with ball bearings; allowance is made for expansion due

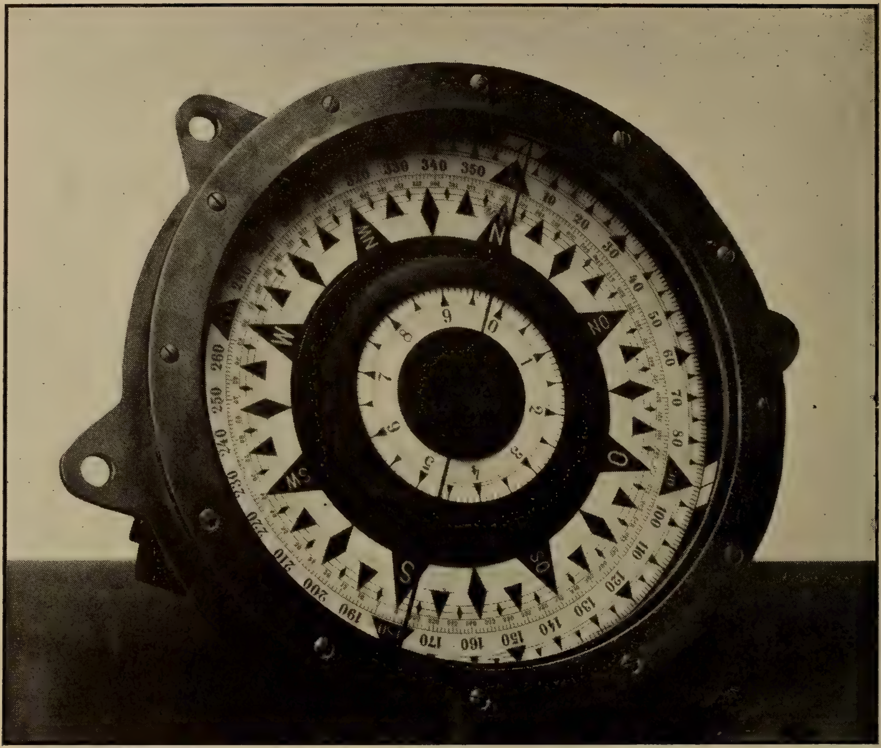


FIG. 8.—THE GYRO-COMPASS CARD

to heat, and means are provided for replacing bearings if necessary.

The axle of the gyro is a flexible one, of the de Laval type, so that the centre of gravity of the whole rotating mass coincides with the axis of rotation as soon as a certain critical speed is attained.

The friction between the suspended moving system and the mercury in the bowl is not sufficient to cause a visible decrease in the amplitude of the oscillations of the gyro on either side of the meridian, and the swinging would be continuous if a damping system were not employed. To

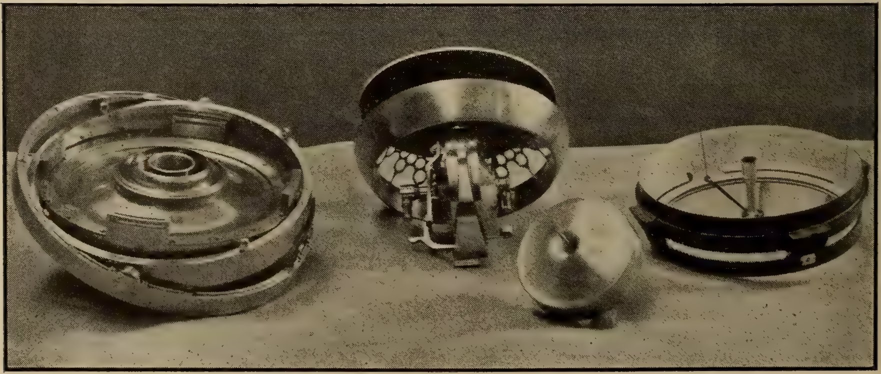


FIG. 9.—THE CHIEF PARTS OF THE GYRO-COMPASS

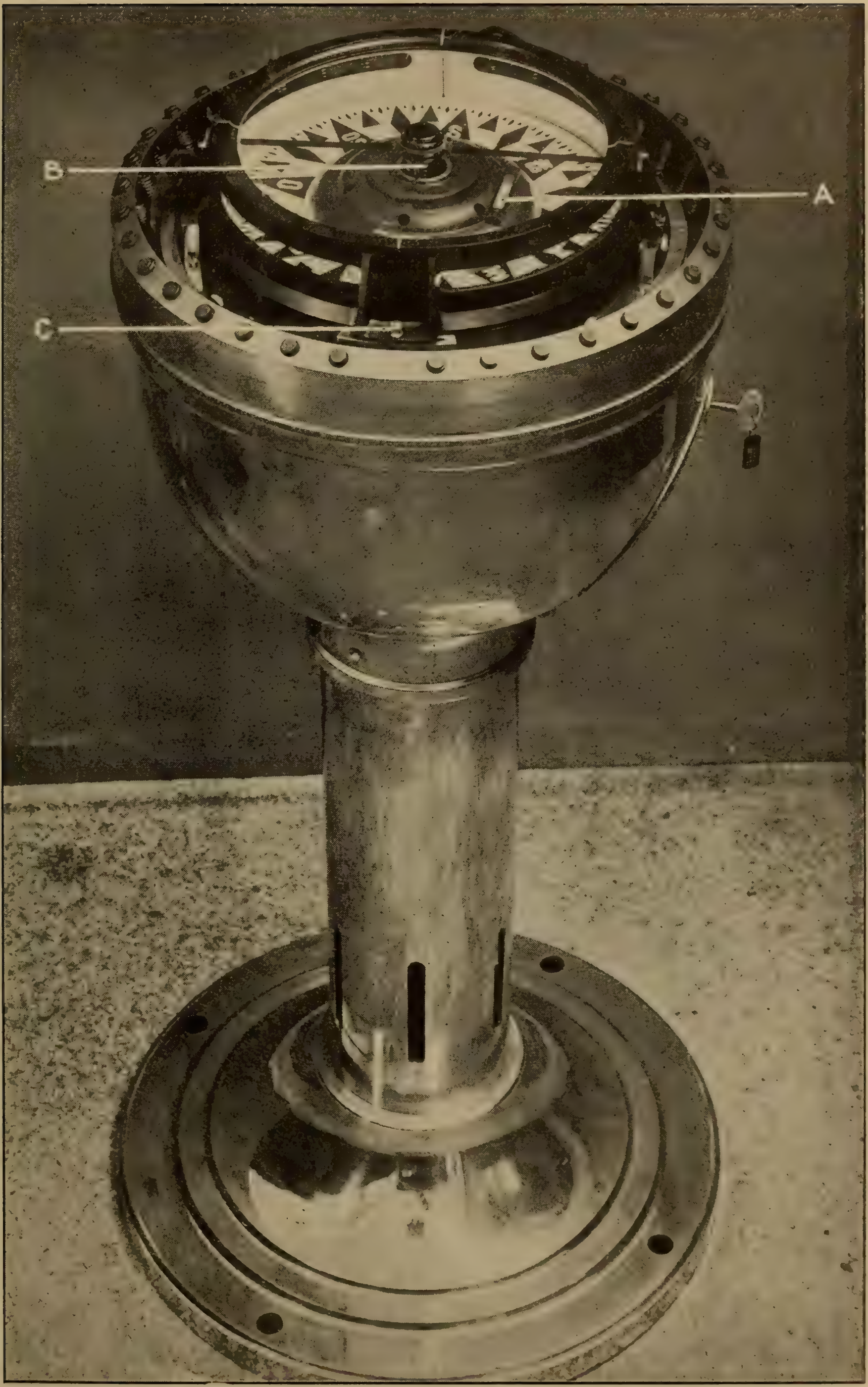


FIG. 10.—GYRO-COMPASS WITH TOP COVER REMOVED

*A*, level; *B*, central stem; *C*, clamp screw for lubber point.

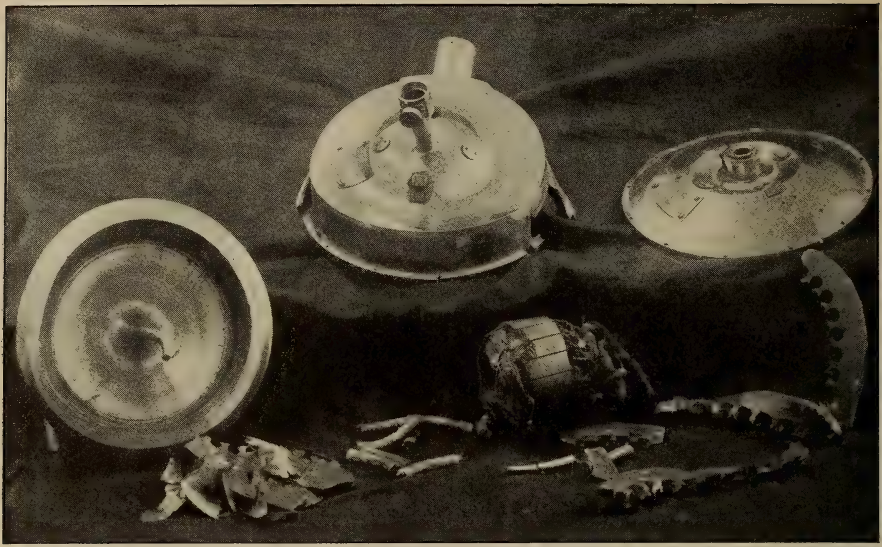


FIG. 11.—GYRO AFTER SPECIAL HIGH-SPEED EXPERIMENTS

The case was twisted, but not torn apart.

damp out the oscillations there is cut near the centre in the sides of the case *P*, Fig. 7, two holes *J* for the admission of air, and on the periphery of the case an outlet is provided. The gyro wheel acts as a high-speed centrifugal blower and a strong blast of air is set in motion which incident-

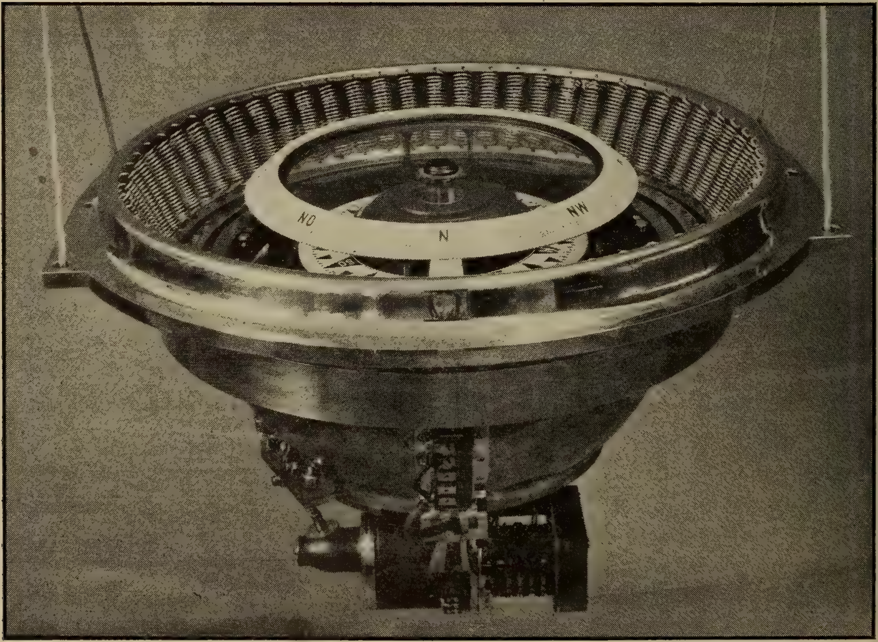


FIG. 12.—BINNACLE REMOVED, SHOWING GYRO AT BASE

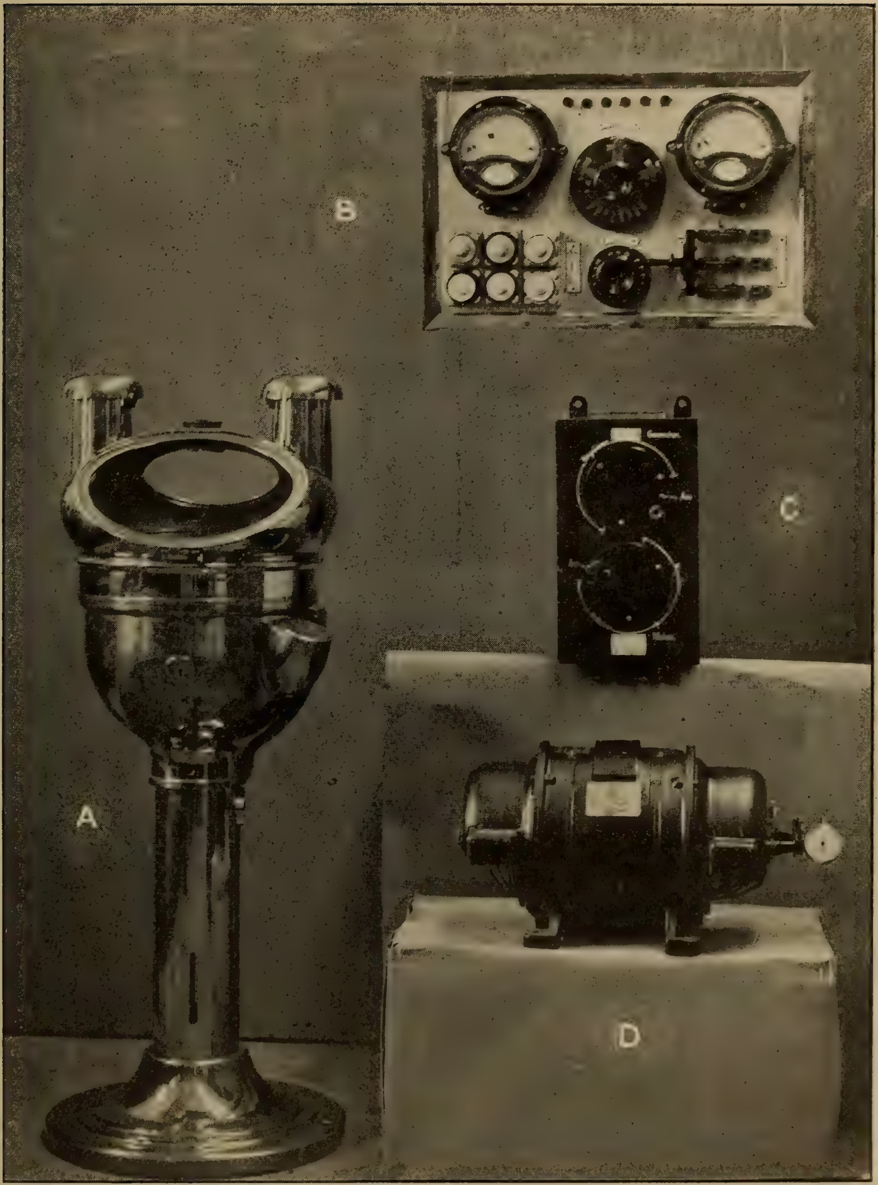


FIG. 13.—ACCESSORY APPARATUS

*A*, binnacle; *B*, switchboard; *C*, regulating rheostat; *D*, motor generator.

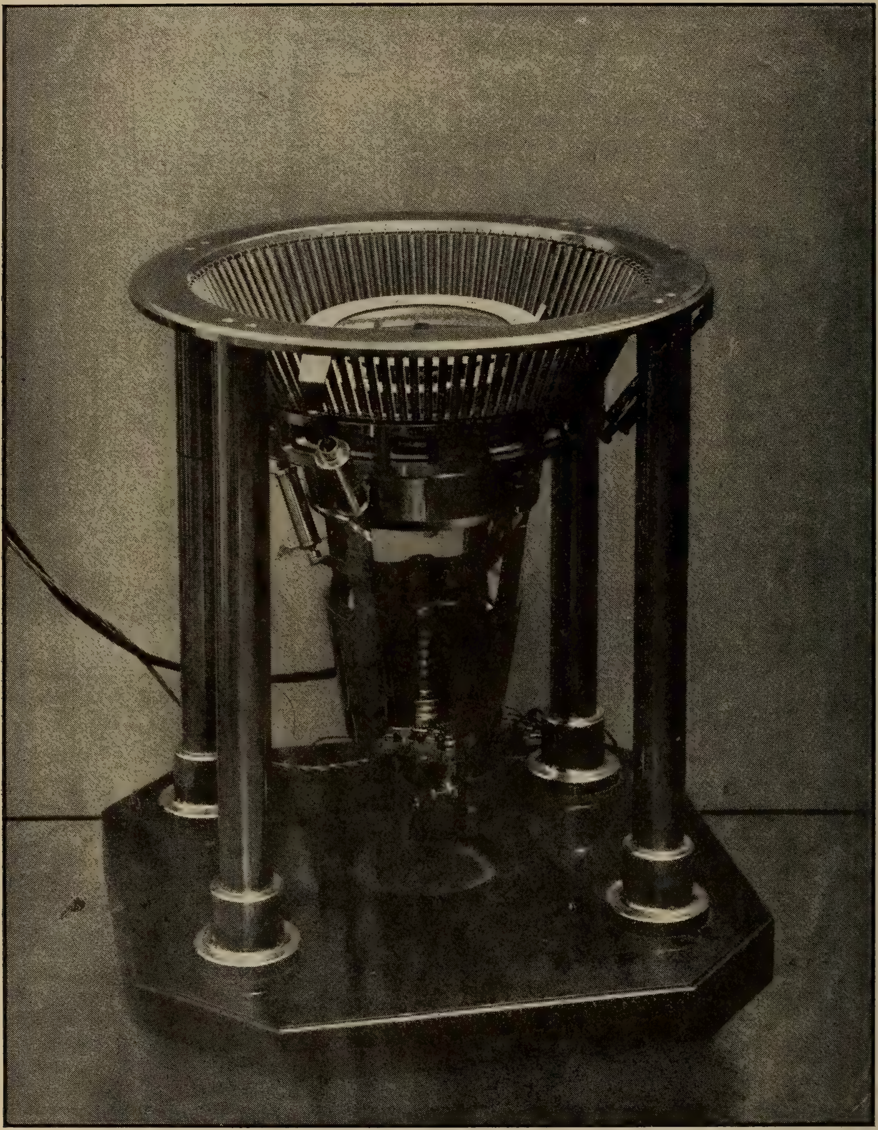


FIG. 14.—GYRO-COMPASS AND PILLARS WITH TOP REMOVED

ally serves to keep the motor of the gyro cool and at the same time is made use of to damp the swinging of the gyro.

A constant stream of air issues from the opening in *c*, and this opening is divided into two parts, *a* and *b*, by plate *a*, carried by the pendulum arm *d*. The arm *d* hangs from accurately-constructed bearings very free from friction, and the arm is so balanced that when the axle of the gyro is horizontal the two openings *a* and *b* are equal and the stream of air divides itself equally between them, one part on each side of a vertical centre line through the whole moving system.

Should the axle of the gyro not be horizontal, which it will be remembered is the case when the axle is precessing to or from the meridian, the small pendulum *d* swings to one side and the plate on the pendulum automatically enlarges one of the openings and closes the other, the two streams of air are no longer equal. The difference of their reaction forms a turning couple round the vertical axis of the system.

Under the influence of this couple a motion is set up opposing the precession in such a direction as to bring the axle of the gyro once more to the horizontal. In this manner the oscillations of the gyro to either side of the meridian are powerfully damped.

Finally, we must take cognizance of one other feature of the gyro-compass, and that is the transmission of direction from a master gyro-compass to a number of smaller compasses or receivers placed in various positions in the ship, such as, for instance, the steering position, conning tower, etc. Since the directive force

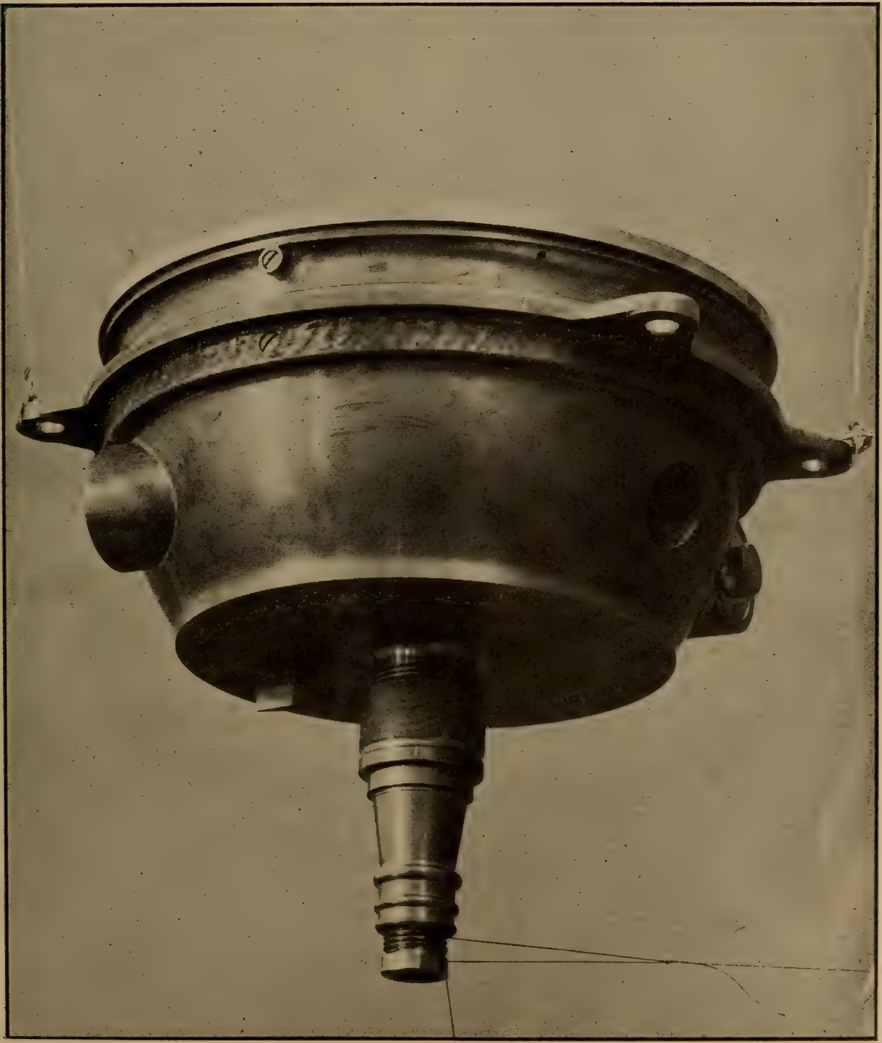


FIG. 15.—A RECEIVER CASE

of a gyro-compass is fifteen times as great as in the case with a good magnetic compass, its movements can be easily transmitted to a number of other compass cards.

Seldom has the application of a scientific principle to a practical problem come at a more opportune time, for until recently the difficulties of applying proper compensation connections to a magnetic compass on warships could be overcome to a considerable extent; but now, with the enormous increase in the size of warships and the masses of moving steel in use in modern guns and their shields, correct adjustments of the magnetic compass become a much more difficult problem.

The Anschütz gyro-compass has been installed on numerous ships of the German and Continental navies, and at this writing apparatus is under construction for the British Admiralty for use on a large vessel. In conclusion I wish to acknowledge my indebtedness to Lord Elphinstone for much of the text used in the foregoing article, and my thanks are also due to Messrs. Anschütz & Co. for the use of the accompanying photographs.

1

# THE GREAT TRANSFORMATION

By Henry Harrison Suplee

## VI.—THE TRANSFORMATION IN DAILY LIFE

ONE of the distinguishing characteristics of present life appears in the extent to which practical applications of scientific apparatus have entered into everyday affairs. It is not so very long ago that the electric light, the electric motor or the telephone appeared only as adjuncts to the display of the scientific lecturer. Even such older appliances as the steam engine, whether on land or on shipboard, were in the hands only of specialists, trained engineers or operators, and looked at somewhat as remarkable things by the layman. The gas engine, and its nimble infant, the gasoline motor, came still later, but they, and most other pieces of mechanical ingenuity, have become very familiar to the public, and been taken altogether out of the class of scientific marvels. To-day the ordinary individual speaks through the telephone, rides in electric cars or gasoline-driven automobiles, turns on the electric light, and rides in an electric elevator, scarcely heeding the fact that these things were the curiosities he stared at only a few years before. The railway, the steamship, the telegraph, have become commonplaces, and even the marvelous fact of telegraphy through space has lost much of its strange novelty.

Few people realize, however, the extent to which these developments of applied science have transformed their habits of daily life. It is necessary for some one of these adjuncts to modernized civilized existence to be cut off before we can be made to understand how necessary it has become to our activity. A fire which disorganizes a telephone central station paralyzes the entire district which it serves; the interruption of service of an electric power plant stops the wheels of industry, checks public transportation, and maroons hundreds of people in the upper stories of tall buildings. Without really appreciating it, we have become so intimately connected in the affairs of our daily life with the continuous operation of a mass of power machinery over which we have no immediate control that our entire conduct of affairs is dependent upon the maintenance of its operation.

Not only is this true of long-known and well-established appliances; it holds good of things which have entered into personal and industrial activity almost as soon as they become known. Within a few years after the production of a really serviceable mechanically-propelled vehicle, the automobile became an established factor in the transportation problem. Its transit through the stages of curiosity, sporting display, luxurious private service, and general public and commercial use was effected with a rapidity equaled only by the general lack of appreciation of its meaning. If to-day the entire mass of motor vehicles in active service were removed the effect would be disastrous; and yet this would mean only a return to the actual conditions of a few years ago, conditions which at that time seemed fairly satisfactory.

In considering, therefore, the probable extent to which travel through the air is to enter into everyday life we may well compare its present status with the corresponding condition of such an innovation as the automobile was in its early history.

The experiments of such pioneers as Daimler, Lenoir, or Benz, and the crude machines in which they made their brief and interrupted trips over quiet highways seemed fully as rash and foolish to their contemporaries as the early flights of the Wrights, of Farman, and of Blériot. Even among scientific men the experimental researches of Langley were regarded askance, and their successful completion obstructed; and many clear-thinking men to-day still hold the belief that aerial navigation will always be kept within close and comparatively useless limits.

Looking, however, at the enormous development of the automobile during the past ten years, and remembering the early incredulity and opposition which it had to overcome, we feel justified in assuming that within a reasonable period of time the machine which has created individual travel through the air will become a factor even more potent in the transformation of society than the machine which can travel only over the roads.

Admitting, then, that there will come a time, probably not very far distant, when free and uncontrolled travel through the air will be made as safe and easy as automobile travel on the surface has already become, we may examine somewhat the nature of the changes which may be expected to follow. Some of these changes have already been indicated in previous articles of this series, especially in connection with the transformations to be expected in government and in architecture. There will doubtless appear a much greater degree of freedom in going from place to place, due to the relief from the necessity of following any particular route or adhering to any definite time table. The latter feature has already shown itself to be one of the most important characteristics of the automobile, and when to it is united the emancipation from highway limitations there must result an independence as to time and place hitherto unknown.

As already pointed out, the influence of this freedom will tend toward decentralization, permitting men to live at such places as may be found most convenient, without the close influence of the location of their business activities. It is quite possible that the cities may become more and more restricted to business and be gradually abandoned as places of residence, a condition which is already beginning to appear in some instances. When a man is able to rise from his own grounds and travel with the speed of an express train in any chosen direction in a machine of moderate cost, operated wholly by himself, there will be no reason why the situation of his manufactory or office should have much influence upon his place of residence.

So far as the operatives in manufacturing industries are concerned, anything which enables the workers in the great establishments to live at a reasonable distance from their work must be recognized as greatly to their benefit. More than a score of years ago the popularity of the bicycle showed its importance in the manner which it enabled workingmen to house their families in pleasant country surroundings and yet travel cheaply, comfortably and healthfully to and from their work. If aerial transport reaches a development at all comparable with that which has been attained by electric traction systems upon the surface of the earth, it should go far in effecting the abolition of unhealthful tenements and insanitary town dwellings.

In considering the influence which the freedom of the air may have upon the subject of crime, it was noted that the entire method of dealing with criminals should be changed in view of the extent to which crime might otherwise get beyond control. If the air is free to all as a route for swift, private, unrestrained travel the only way to prevent a relapse into uncontrolled license would appear to lie in the removal of the influences which develop evil tendencies. Probably the most important element in this change will appear in the elimination of the crowding which has for so long been productive of debasing influences. The whole effect of the decentralizing action of transport facilities should aid in the removal of the training in crime which so often accompanies congestion in unwholesome districts, and thus, by removing the cause, do far more for the prevention of crime than the unauthorized use of the new transport facilities will add to its commission. An interesting analogy to the possibility of unlimited transport through the air is seen in the manner in which the development of the motor boat has expanded the scope of life in the neighbourhood of suitable bodies of water. So long as the residents by the sides of lakes, rivers and conveniently navigable coasts were dependent wholly upon the facilities afforded by regular public steamboat lines the necessity for concentration about the determined landing places created and maintained the towns and settlements thus served. With the advent of the motor boat, however, there was placed at the service of almost every householder the ability to go and come at will from any point on the water's edge to any other point. The result has been the development of widely-extended residence areas, tributary to definite centres, it is true, but at the same time possessing a degree of independence which would have been impossible before the motor boat became available. A similar but far more widely-extended influence must follow the possession of the individual of the means of passing through the air with freedom. If the ownership of a piece of land on the margin of a navigable body of water and the possession of a motor boat with which to reach it make such a change in the entire social system of a locality, what may not be expected when that navigable body becomes the entire atmosphere and the locality becomes the whole surface of the earth?

The whole idea of the freedom of the air includes an emancipation from a vast number of individual restraints, restraints to which we have been so long accustomed that we have regarded them almost as essential features of daily life. This is especially true of those countries in which a close personal supervision is even yet maintained over the movements of individuals, and in which police surveillance and the inspection of passports remain in force. At the present time one of the great nations of Europe requires an official verification of the religious faith of the traveler as one of the conditions of entrance within its boundaries; while in others a report of identity must be placed in the hands of the police shortly after arrival. Although such mediæval restrictions as these are now fast disappearing they serve to indicate the disposition which obtained in many lands when the power to enforce such rules existed. The general use of the aerial highway, however, must render all such attempts at individual control futile, so that all countries will be placed upon a uniform basis in this respect. There are other restrictions, however, which have been imposed, not by governments or police officials, but by social usage, which will be removed under the new order of things. As the young man is supposed to attain an extended degree of freedom when he is given a latch-key to his father's house, so that he may come and go at will, so the individual with an aeroplane may ascend to his roof and depart, no man knows whither, or return unseen from parts unknown; free, to an extent hitherto impossible.

The influence of such changes upon general family life need not be of a disintegrating character; this will depend, as formerly, more upon the individual than upon the apparatus. Family life, as it existed before the introduction of the railway, the steamship, or the automobile, was contented, happy and permanent, or disturbed and unsettled just in accordance with the disposition and character of the individuals of which it was composed. To-day we observe the association of the motor car with quiet and satisfactory family life, or with disorderly and reckless conduct, the controlling element always being the disposition of the human, and not the mechanical element.

In some respects it may be assumed that the general use of the aerial machine will act to reduce privacy by preventing any effective rules against trespass, and by laying open much of what has hitherto been held as private property. As an offset to this, however, the extent to which aviation will aid in the dispersion of private residences to more widely separated districts must be taken into account, and it is probable that the gain on the one part will be as great as the loss on the other.

In general the changes in daily life which may be expected as a result of the development of aviation are closely bound up with those already indicated as impending in commerce, government and architecture. With universal freedom in traffic, including the removal of all restraints involved in the existence of national boundaries or artificial organizations, and with the immensely simplified form of government following upon the removal of many of its powers and responsibilities, the conditions of daily life will naturally tend toward the development of individualism. The changes in the character of buildings under the changed methods of access should lead to a more healthful, moral and happy life, and thus react upon the tone of the entire social order. With this must come the broadening educational influence which has always followed the opportunity for familiarity with the conditions of life in more than one locality, and with the freedom from a narrowing effect of provincialism.

The social life of the future will be better, stronger, more inspiring and broader with every appliance provided by science for freer communication and transport. This has been the influence of the railway, the steamship, the telegraph, the telephone and the automobile, and it will be so to a still greater extent with the freedom of transport through the air.

(To be Continued.)

# MAGNETIC ORE DRESSING

By R. Cyril V. Whitfield

WHILE the world's production of pig iron is yearly increasing there is no corresponding increase in the exploitation of rich iron-bearing deposits to supply the demand for comparatively pure raw materials, and the ore deposits now being worked are, with few exceptions, gradually deteriorating in quality.

Makers of pig iron are to-day faced with the fact that ores are smelted as mined, and, if necessary, calcined, at a gradually increasing cost per ton of iron produced, and the problem of prime importance to the iron maker is that of treating his raw material before charging into the blast furnace by some method which will appreciably lower the ultimate smelting cost, though the cost of operating such a process will at first sight tend to increase that cost.

Mr. T. C. Hutchinson, managing director of the Skinningrove Iron Company, in a paper on "The Mechanical Cleaning of Iron Ores," said:

"After many years of careful observation and comparison of costs of smelting ores containing varying proportions of impurities admixed with the ironstone I have come to the following conclusions:

"1. That whether these impurities are charged into the furnace in larger or smaller percentages, as compared with the main bed of ironstone, the coke and limestone requirements and the cost of smelting increase in exact ratio.

"2. That it is cheaper to pick out impurities mechanically than to smelt them out in the blast furnace.

"3. That mechanical cleaning is desirable and can be applied to all descriptions of ores used in the manufacture of pig iron."

The tendency in iron manufacture to-day is ever towards increased production of pig iron per furnace, this being attained by harder driving, etc., and the forcing of the rate of production is directly a contributory source of increased iron losses, the ores as a rule disintegrating in the upper regions of the furnace and the larger and more rapidly moving volume of gases carrying a greater proportion of the valuable content of the ore, in the form of fine dust particles, into the gas tubes of the furnace plant.

Proof of this is found in the fact that in the tubes of slow-driving furnaces the dust may contain as low as 5 per cent. of iron, but in modern furnaces, using high-blast pressures, instances are on record where over 30 per cent. of iron has been present in the dust, this being the equivalent to a low-grade ore in iron content.

Any means of ore treatment has to fulfil the following conditions:

1. It must apply to iron ores in general.

2. The cost of operation must be low.

3. The product must be such that iron losses will be reduced in the blast furnace.

4. The product must be high in iron and low in phosphorus, sulphur and gangue matter.

Such being the case the process of greatest commercial value and importance is that which will remove the bulk of the earthy matter from an ore at a minimum cost, and, further, present the cleaned and enriched material in such a form that final preparation will give a lumpy product, free from dust, and in such a condition that it will not easily disintegrate in the upper parts of the blast furnace and will be permeable by the ascending furnace gases.

Many processes have been devised whereby iron ores could be in part cleaned and separated from the contained impurities, some being successful only under special conditions and others being only capable of operation at too high a cost for commercial practice.

While washing processes and hand-picking schemes have many points in their favour their application is restricted, as iron losses in the separated gangue matter are unavoidable, and the loss in this manner may be a serious item.

The one mechanical process applicable to all ores, and the one process whereby, if carried out in a proper manner, iron losses may be reduced to a minimum, is that of magnetic concentration, with its coincident operation of magnetic separation of materials having varying degrees of magnetic permeability.

While it is admitted that all natural ores do not lend themselves to magnetic treatment, there is no reason to doubt that all ores, with few exceptions, are susceptible to such treatment that cleaning processes, based on magnetic attraction of iron particles, can be applied successfully to the cleaning of the iron component, and at the present day there are a large number of cleaning plants in operation all over the world and working successfully on varying grades of ores.

All ores of importance in the manufacture of pig iron may be arranged in the following general classification, depending on the form in which the iron exists in the ore:

1. Magnetites, the richest and generally the purest of iron ores, in which the iron exists as magnetic oxide, $Fe_3O_4$, though the oxide may be partly replaced by chromite, $Cr_2O_3$, FeO: franklinite (ZnFe), O, $Fe_2O_3$: or ilmenite, $TiO_2$, FeO, and as these are ferro-magnetic in strong fields the iron component of the magnetite cannot be isolated by simple magnetic separation.

2. Hematites, in which the iron exists as ferric oxide, $Fe_2O_3$, in either the hydrated or anhydrous conditions, these forming the bulk of the ores used in iron manufacture.

3. Spathic ores or ferrous carbonates, in which the iron exists as ferrous oxide, FeO, in combination with carbonic acid and in many cases associated with bituminous matter or clay, e. g., the "blackband," and clay ironstones.

Magnetites, in which the iron exists as a natural magnetic oxide, require only a preliminary crushing and sizing before subjecting to magnetic separation, but those ores in which the iron oxide is non-magnetic and which comprise the greater proportion of the ores used to-day, require such preliminary treatment that the iron oxide may be converted to the higher magnetic oxide, and this is best attained by a preliminary roasting at a moderate temperature in the presence of free carbon or in an atmosphere containing a large quantity of CO, the reactions being in accordance with the formulæ:

$$(1)\ 3Fe_2O_3 + C = 2Fe_3O_4 + CO$$
$$(2)\ 6Fe_2O_3 + C = 4Fe_3O_4 + CO_2$$
$$(3)\ 3Fe_2O_3 + CO = 2Fe_3O_4 + CO_2$$
$$(4)\ 3FeO,CO_2 + 2C = Fe_3O_4 + 5CO$$

To completely effect this conversion of the iron oxide to the magnetic condition it is necessary to crush the ore to a moderate degree of fineness, say to pass through a ¼-inch mesh screen, and to heat evenly and regularly to the required temperature, usually a bright red heat, in specially constructed furnaces arranged so that air does not enter the converting chambers. Crushing is necessary to insure the complete conversion of the oxide content, large and lumpy ore not being suitable by reason of the reduced permeability to the gases in a given time.

There are some typical ores, as, for instance, the Cleveland ironstone, to which such process would not apply by reason of the extremely complex condition in which the iron oxide exists, each particle of oxide being encased in a siliceous covering, and an important problem to be approached in the near future is the economical separation of this siliceous material to render the ore susceptible to magnetic treatment.

Granted the iron oxide can be obtained in the magnetic form, the operation of magnetic separation is a comparatively simple matter, and there are many types of machine designed for this work and in operation on ore at the mine in all the chief ore-producing countries of the world, with results that are open to all investigators.

Machines designed for the magnetic treatment of iron ores vary considerably in general details, but, as a machine designed to efficiently perform certain operations, the magnetic separator has reached a high level of development, it being economical of power for the exitation of the magnets and for operation, is not liable to break down under temporary abnormal conditions, and is easy to operate.

Magnetic separation and specific gravity processes have many points of resemblance, with the advantage considerably in favour of the former, the one essential difference being that while the one relies on the different specific gravities of the materials treated the other relies on the varying degrees of magnetic permeability.

In magnetic separation as a process it is important that the material to be separated is presented to the magnetic field so that every individual particle is free to the magnetic influence, and the feeding device must be so constructed that the ore is delivered in a thin, even layer or sheet, theoretically only one particle thick, but in treating the richer magnetic ores this thickness may be considerably increased, though there is then a liability to carry non-magnetic particles with the magnetic portion when

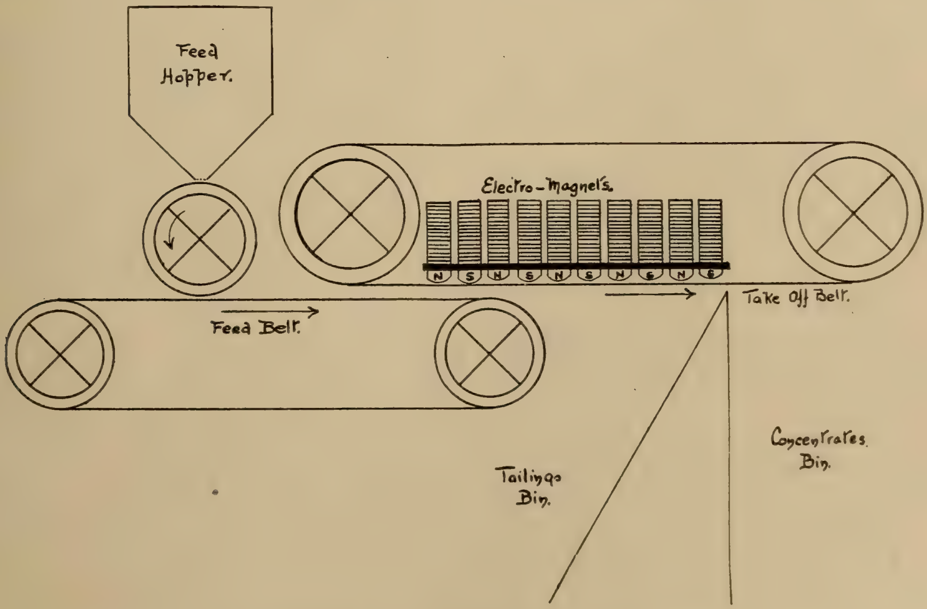


FIG. 1.—DIAGRAM OF THE BALL-NORTON BELT SEPARATOR

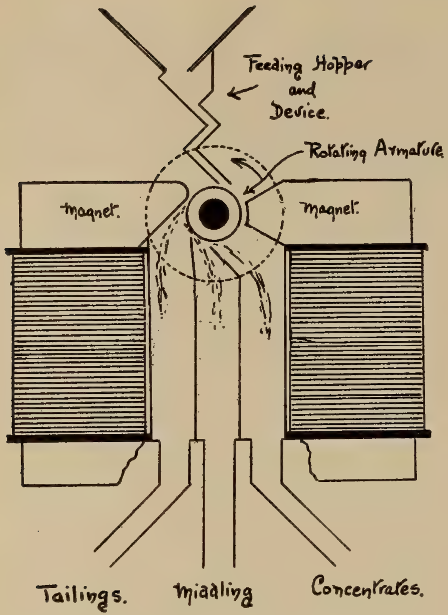


FIG. 2.—DETAILS OF THE WETHERILL TYPE F SEPARATOR

in the magnetic field, this leading to poorer concentration, and for this latter reason it is necessary to crush the ore to such a degree of fineness that the magnetic content is detached from the gangue matter and the ore then consists of an intimate mechanical mixture of the two materials.

The speed at which the ore is presented to the magnets must be such that sufficient time is given to every particle to come thoroughly under the magnetic influence, differing materials having great variations in the time necessary for magnetic induction, and for this reason those machines in which the ore is presented as a thin sheet falling past the separating poles are limited in their application to those materials of high magnetic permeability.

The intensity of the magnetic field should be capable of adjustment to any required degree and at the same time should be uniform in intensity.

As a general rule the raw material should be presented in a dry condition, this usually necessitating a drying plant in which all moisture is removed without adversely influencing the magnetic properties.

That efficient magnetic treatment of iron-bearing materials is the subject of careful investigation is evidenced by the fact that up to date there have been granted over two hundred patents in this and other countries and dealing with this subject in detail, and though the greater number of these ideas are not commercially possible there are in operation to-day many types of machine working economically on ores and materials of widely differing composition, with results seen in the form of briquettes used in every iron-making centre, either alone or as a proportion of the blast furnace burden.

### THE BALL-NORTON BELT SEPARATOR

In this machine the feed of ore from the hopper is regulated by a feed roll, and the lower horizontal belt carries the ore into the magnetic field. The magnets are so arranged that opposite poles are presented to the ore, thus permitting a thorough turning over of the particles while in the magnetic field and allowing entrained non-magnetic particles to fall from the magnetic portion.

A suitable stop or barrier is placed in such a position that the falling streams of concentrates and tailings are efficiently separated (see Fig. 1).

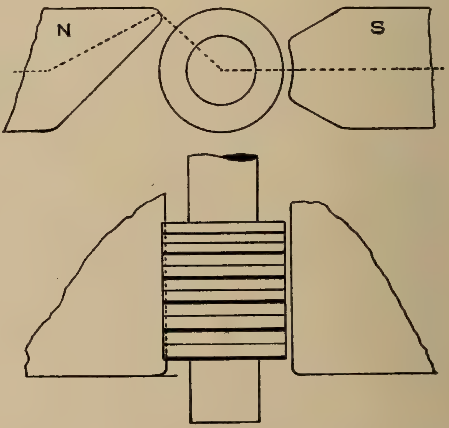


FIG. 3.—DETAILS OF REVOLVING ARMATURE AS USED IN THE WETHERILL TYPE F SEPARATOR

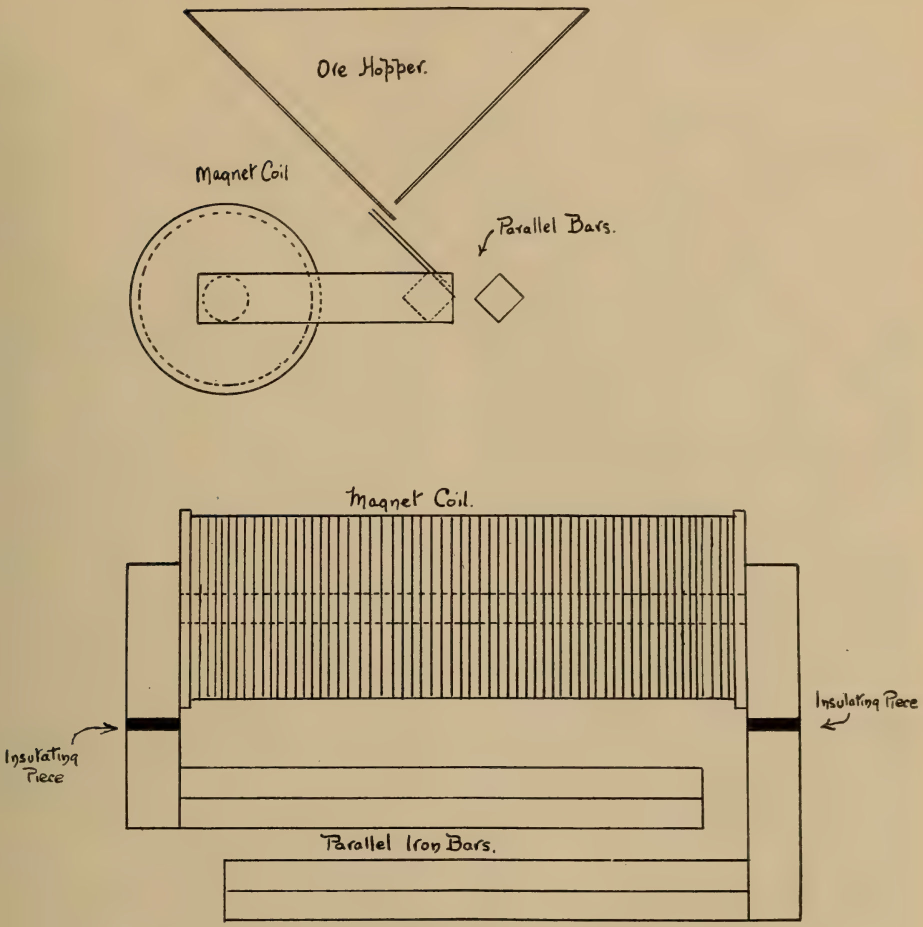


FIG. 4.—ELECTRICAL ORE AGGLOMERATING FURNACE

Machines of this type are built to treat 20 to 35 tons per hour of magnetic ore, crushed and screened, through ¼-inch apertures.

Fig. 2.—The Wetherill Type F Separator, comprising a separating armature built up of alternate discs of magnetic and non-magnetic material and revolving between the poles of a primary magnet.

Secondary poles are set up at the edges of the magnetic discs, causing magnetic particles to stick to the armature until beyond the primary poles and until the neutral point is reached, when the material changes polarity, and, in so doing, falls off into a receiver below. The waste falls direct off the armature into a separate hopper.

The capacity of these machines is large, as much as 400 tons having been treated in twenty-four hours.

Fig. 3 shows details of revolving armature with alternate plates of magnetic and non-magnetic material, as used in the Wetherill Type F Separator.

The Edison separator consists of a number of bar magnets, in front of which the ore is allowed to fall in a thin sheet, the magnetic influence being such that the magnetic particles alter their trajectory, though not sufficiently to allow them to touch the magnets, and the falling ore is so divided into two falling streams, which are collected in suitable hoppers.

Machines of this type have a capacity of about 1 ton per hour of concentrates.

Final treatment of the concentrated portion of the ore may be by some method of briquetting, with or without a binding medium, or by some electrical process of agglomeration.

In the manufacture of briquettes without a binding material the briquettes may be mixed with water and compressed at a pressure of 5,000 to 6,000 pounds per square inch, afterwards being heated strongly to knit the ore particles together, but where the ore contains a small percentage of clay the heating temperature need not exceed 75 degs. C. and the pressure 4,000 pounds per square inch. The great objection to the use of briquettes with no binding material is their extreme liability to deterioration by weathering and to crumbling when subjected to the abrasive action of the stock in the blast furnace, and this same objection applies, though not to so marked an extent, to those briquettes in which binding materials are used.

Of binding materials, slaked lime has been used with considerable success, though the use of burnt lime has not proved commercially successful. Gypsum and cement have also been used to some small extent and more success has attended the use of mixtures of lime and sand.

Basic blast furnace slag, magnesium chloride, organic matters, molasses and paraffins and resinous materials are also used to greater or less advantage.

The cost of briquetting, exclusive of general expenses, royalties and redemption, etc., runs from 3/6 to 5/ per ton of concentrates.

As an alternative to briquetting the concentrated (magnetic) ore particles may be agglomerated by centering at a temperature of from 800 degs. C. to 1,000 degs. C. in suitable rotary roasting furnaces after mixing the fine ore with a proportion of coke dust in order to reduce the oxygen in the ore. Certain mechanical difficulties, however, have prevented such processes being extensively adopted, viz., the temperature in rotary furnaces is difficult of regulation and the agglomerated ore tends to adhere to the furnace lining, so being a source of considerably increased expenditure in cleaning the furnaces.

While methods of ore agglomeration or other furnaces heated by coal or coal gases are open to serious objections, there is no reason to doubt but that electrical agglomerating processes will be sufficiently improved mechanically to efficiently and economically treat iron ore concentrates and give a product in every way suited for use in the iron blast furnace. In Fig. 4 is shown an electrical agglomerating furnace, consisting of two parallel iron bars forming the poles of a powerful electro-magnet. The fine ore concentrates, falling on the bars, bridge over the gap between the poles and so permit the main fusing current to flash across the ore bridge, partly fusing the ore particles which then fall clear of the gap into a hopper or suitable molds placed directly underneath. A furnace of the type shown with bars 6 feet in length will agglomerate 20 tons of concentrates per twenty-four hours with a current cost, depending on the cost of supply, of from 2/6 to 4/ per tone of ore treated.

The whole question of ore treatment is becoming daily of increasing interest, especially to those districts in which are situate large deposits of low-grade ore, and to those iron-making centres where low-grade ores are smelted and where the cost of carriage, cost of smelting and other charges are slowly but surely increasing as the iron content of the ores decreases, while the selling price of the iron shows no corresponding increase, but, rather, is steadily declining.

# SECRETS THAT GO DOWN TO THE GRAVE

By Charles B. Hayward

IN a private and closely-guarded room of a small shop in an unknown Swedish hamlet there toils a man in secret. The result of his labors is known and appreciated by machinery manufacturers the world over, and nowhere more so than in the United States—the reputed home of accuracy in machine manufacture. Just how he accomplishes what he does no one knows, not even his own sons who work with him. Probably they never will know, for Johannson's secret will doubtless go to the grave with him, adding another item to the debit side of the ledger of the world's industrial assets, for history shows that secret processes, once lost, are usually gone forever.

Johannson has made the world beat a path to his door in Eskilstuna, Sweden, for he discovered the secret of making a more accurate limit gauge than any previously in use. Not alone a single gauge, but a set of gauges, and a unique system of employing them, by means of which eighty-one gauges are capable of producing 80,000 gauge sizes, accurate to one ten-thousandth of an inch—much less than the proverbial hair's-breadth. It is known as the Swedish combination gauging system, and a single set of gauges gives a practically unlimited series of sizes rising by increments of one ten-thousandt of an inch to 26 inches. A definite figure has been set as the limit of the number of combinations obtainable—80,000; but this is a calculated result and life is too short to prove its truth in practice, as repeated attempts have failed to cite a dimension within the limits of the gauges which they are not capable of producing.

Extreme accuracy is the greatest desideratum in the building of machinery of almost every class, and particularly motor cars, but no such thing as perfect accuracy is commercially, if humanly, practical. The first step toward the goal is naturally the perfection of a standard, for the work cannot surpass the criterion by which it is judged. Making such standards is a tedious and expensive process. Evidently Johannson has either not found it so, or he values his secret but little, for he is able to pay Uncle Sam 45 per cent. of the selling cost of a set of his gauges at home and still offer them in the American market for a few hundred dollars. An American concern of long standing and international reputation is reputed to have said that it could not reproduce a set of gauges of similar accuracy for many times their selling price.

When two of these Swedish gauges are "wiped" together so as to exclude the air from between them they adhere with a pressure which experiment has shown to exceed 30 pounds to the square inch. The pressure of the atmosphere is less than half this. Whence this mysterious force that is equally powerful? It is very difficult to explain. Certain it is, however, that magnetism has naught to do with it, for the pieces have no attraction whatever for one another unless thus "wiped" or "wrung" together. An indefinite number of combinations may be subjected to this test, or twenty or more pieces may be thus wiped together and supported horizontally by merely holding the last one, which means that the accuracy of their various surfaces is almost absolute. Finishing one surface, or two surfaces, to a very close limit by lapping—rubbing together with a fine abrasive between—is a comparatively simple matter. But achieving such perfect parallelism as is shown by these remarkable gauges is quite another thing, a secret quite well worth knowing.

The peculiarity about this mysteriously powerful adhesion of the separate pieces is that the *feel* of the built-up gauge thus formed is exactly the same as that of a single piece of metal, and this holds for any combination, the number of pieces forming it not affecting the sensation in the slightest. Any skilled mechanic will understand instinctively the meaning of this and its testimony to the accuracy of the gauges. For instance, a 1-inch gauge may be built up of pieces representing 0.5 + 0.2 + 0.05 + .150 + 0.1 inch, and the resulting piece will be 1 inch, absolute. Or any one of several other combinations may be made to represent an inch, and, blindfolded, the most expert mechanic could not detect any difference between the manner in which this composite inch gauge and the one-piece inch gauge fitted in a snap gauge of the same size. It would be an easy matter to confuse the two in handling.

The fact that perfection of accuracy is almost unattainable has already been referred to. A ten-thousandth part of an inch is about as close a limit as can ordinarily be set, and it is not commercially practicable to obtain such a dimension absolutely. There must be a tolerance within which the piece may approach to the dimension set and still be acceptable. For coarse work this may be 0.01 inch; if finer, 0.001 inch; or, where the greatest accuracy possible is desired, within a few ten-thousandths, plus or minus. That is, the piece may be 0.9998 inch, or 1.0002 inch, which would mean a tolerance of 0.0002. Many parts of automobile and aeronautic motors are finished to a tolerance of 0.001 or less, and the ball-bearings supporting their revolving members are finished to the finest practical limit. Say a piece is dimensioned on the working drawing as 1⅝ inches—.002, or a tolerance of two-thousandths of an inch. The gauges representing 1 inch + 0.5 + 0.123 gives this exactly, and in a similar way any size may be obtained by rising by thousandths or ten-thousandths of an inch. Moreover, the gauges themselves are self-checking. If a built-up gauge does not agree with the single gauge of corresponding size, the incorrect increment causing the error may readily be determined by a simple process of elimination.

Mr. Johannson, the backwoods inventor, who discovered what thousands of the most expert mechanics in machine-building centres have vainly sought for half a century, limits his output to a few hundred sets of gauges a year; whether purely from inclination or because of mechanical difficulties in production is as much a secret as the process itself, and one that he will doubtless also take with him when he goes Beyond.

At the Paris Exposition, in 1900, there was exhibited an assortment of marquetry work of marvelous intricacy of design and beauty of finish, but at prices so low as to cast reflection upon its genuineness. Many of the pieces were of duplicate pattern. Here is another industrial secret of considerable value that doubtless is destined to go to the grave with its discoverer, if it has not already done so. No amount of examination, no matter how searching, sufficed to reveal the manner in which the designs of table tops were duplicated with such marvelous accuracy.

That much the inventor, an Austrian, was willing to divulge. The pattern, instead of being made singly of the thickness requisite for the piece it was intended to ornament, such as a table top, was built up of pieces 2 or 3 feet long, from which sections were then sawed off. How this composite structure was held together was quite another matter. Interest in the invention reached a point where the Austrian Government offered its discoverer a small fortune, on condition that his secret be deposited, sealed, in the royal vaults, in order that it might be known after his death. He was to have the sole right of manufacture as long as he lived, the secret not to be revealed until after his demise, but he preferred to keep it locked up in his own head.

One of the dead secrets that literally went to the grave with its possessors and has not since been rediscovered, though centuries have elapsed, is the art of embalming as practiced by the ancient Egyptians. As a race they appear to have been responsible for not a few of the lost arts, knowledge of some of which would greatly enrich the industrial world of to-day. The manufacture of a paper as enduring as papyrus is not the least of these. Of rather more academic interest, and one that has puzzled the minds of the best mathematicians for ages, is the method that was employed to raise the huge masses of stone of which the Pyramids are constructed. Innumerable theories have been advanced, but, like the lost art of embalming and the exact manner in which artificial incubation was carried on in ovens so many centuries ago, this will probably always remain a buried secret.

Just how much the world loses every century in untransmitted discoveries can be only a matter of conjecture, and it is one with which many absurd fallacies are interwoven. At almost regular intervals the announcement comes forth that some investigator has rediscovered the long lost art of tempering copper, and a glowing account of the possibilities of the newly-resurrected secret and its influence on the industrial world is appended. Despite these periodic outbursts tempering copper appears to be as much a lost art as it ever was, but its revival at the present day would make the process merely one of scientific interest, the practice of which would be confined to the laboratory. It represents one of the few buried secrets, the economic value of which has long been superseded by the discovery of other materials and processes.

The millions that await the rediscoverer of the art of tempering copper exists only in the minds of those who do not realize that steel has usurped the place that hardened copper enjoyed so long ago, and that, like the method of constructing the Pyramids, it is a secret that it will not pay to disinter.

# LIVE-STEAM HEATING OF FEED WATER

## IS IT ECONOMICAL?

By John Batey

THE claims made for an increased efficiency of steam boilers by the use of live-steam feed have no doubt been made in good faith, but unfortunately this method is contingent upon supplying heat, which must be paid for.

During the making of steam with a cold feed, by any particular generator, when referred to a live-steam feed, for the same boiler, unquestionably the advantage is in favour of the latter.

As a fact, there is nothing in a hot feed, so supplied, to account for actual economy, because it matters not whether the feed is supplied with heat when outside of the boiler or inside, the same quantity of heat units are needed, and it does not alter the fact, whether the steam for heating is supplied from the main generator or an auxiliary, the value of the heat incorporated is the same.

It seems unnecessary to refer to the actual conditions of steam formation, because these are supposed to be at the finger ends of all who have aught to do with steam boilers, yet, in spite of this knowledge, the advocates of live-steam feed claim increased actual efficiency by its use, meaning that 1 pound of coal utilized in live-steam feed boilers is capable of utilizing the heat to better advantage, or, in other words, more pounds of water can be evaporated per pound of fuel.

It is in regard to this claim the present examination is made. The whole question resolves itself into heat value, say the average estimated heat value of 1 pound of coal equals 14,700 British thermal units; then that is maximum heat available.

To assert that 1 pound of steam, being part of the effect derived from the combustion of 1 pound of fuel, when projected into 1 pound of water feed, is going to produce more heat (which must be the meaning if a claim is made for increased efficiency), is an assertion which is neither reasonable nor tenable.

When water is evaporated in a boiler into steam its formation from, say, 32 F. to steam of 381.7 F., or 200 pounds absolute pressure per square inch, is produced under recognized conditions.

The original units of heat in the water were 32 British thermal units, whereas they are now 1,229.8 units, or 1,197.8 units have been added, resulting in an increase of temperature of 349.7 degrees F., or equal to nearly 3.4 units per degree.

Two effects have been produced. Roughly, 27 cubic inches of water has been increased to 2.26 cubic feet, under an increasing pressure, from 14.7 to 200 pounds per square inch.

But in a boiler the increase has been made against 200 pounds absolute pressure, and 27 cubic inches have become 3,095 cubic inches, or approximately 916 British thermal units have been utilized in doing work. As heat it has become latent, or rather it is engaged in upholding the column of the increased volume; hence about 281.5 units are taken into temperature, equal to 0.8 units per degree per pound weight of vapour.

These are the conditions. Subject to no loss of heat, 1 pound of steam is capable of imparting heat to 1 pound of water through a given number of degrees, but as 2 pounds of water the temperature is less in the proportion of 1 to .8, being the specific heats of the extreme temperatures. By giving up heat the steam loses volume, but this decrease of volume represents a greater quantity of heat to produce 1 degree of temperature, though the actual heat value, as units, is the same.

The latent heat in the steam is utilizable conditionally. The point at issue is that 1 pound of steam under 200 pounds absolute pressure has an estimated heat value of 1,197.8 units above 32 F., and to increase its temperature 1 degree, only 0.8 units of heat is required, whereas as a liquid 1 unit is needed.

It is quite obvious that live-steam feed as such cannot result in any saving of fuel, whatever else it may effect.

There is one point—as a fact, increase of temperature means less radiant heat; the condition proves it, because less heat per unit weight is needed per unit rise of temperature; therefore the value of the heat effect at the higher temperature is greater than at a lower.

Live-steam feed, supplied at nearly the working steam temperature, if taken from another generator, must result in the main boiler making more steam per pound of coal, because part of the heat is supplied from another source, but the evaporative capability of the fuel has not been increased, because the same amount of heat value has been imparted, neither more nor less, though the evaporative efficiency of the boiler has been increased as to quantity in a given time, but nothing else; hence no economy has been effected, and to say so is not true.

It is quite evident that a live-steam feed cannot have any direct bearing on economy of fuel consumption.

Where economies of 10 to 12 per cent. have been obtained under live-steam feed conditions, the economy must be looked for from some other cause than that attributed to the use of live steam; that is, the economy arises from another cause.

Experimental tests are always conducted with attention to details and care, in which are included clean boilers, more or less picked fuel, and careful stoking. This latter is the best means of attaining economy, and to such is the probable economy; not to live-steam feed.

Live-steam feed, or high-temperature feed, may be instrumental in avoiding the cooling down of heating surfaces in local places, whereby the gases are not influenced to cool or produce smoke, and besides does not lower the efficiency or reduce the economy. This lowering of efficiency may be brought about by the method of feeding fresh water, such as projecting the feed onto the crown of the furnace, which is a most pernicious habit, if for no other reason than interfering with the circulation of the dead water beneath the flue.

All feed should be sprayed into the boiler, whereby local effects would be mitigated, if not altogether avoided.

Circulation is an important factor, economical, and insures movement of any gases that may tend to form, and tends also to the safety of the structure; it displaces newly-formed bubbles of steam to make room for others; it tends to keep local conditions equable, and, though the temperature is different in one part than another, each part keeps its own temperature, and circulation is ensured.

Dead water lying in the bottom of a boiler is to be cendemned, whether it be hot or cold feed, because all water carries the potentials of harmfulness if allowed to gather, which pocketing does permit; this circulation destroys.

Heating feed water before it enters the boiler is decidedly economical where it is effected by waste heat, be it gas or steam, the waste products of combustion or exhaust steam.

The question of economy is relative. It does not necessarily follow that a boiler is the most economical because it makes 1 pound of steam cheaper than another, because, as an impartial statement of fact, it can be proved that the cold feed may be strictly the most economical in regard to fuel, whilst it may be wasteful, measured by money value.

Steam, as vapour of water, takes all the heat given it, and probably this is about 75 per cent. of all the estimated heat of the fuel put into the furnace, but 5 per cent. of the fuel credited to any boiler may never go in, but may be found in the ash-pit as small coal; hence about 30 per cent. of all the fuel is not available for heating the water and making steam.

It is quite true to say that a cold-feed boiler cannot evaporate as much as a hot feed for the same boiler.

Water takes in heat until 212 F. is reached, but it continues to take in heat until it is all evaporated or vaporized, but it is still 212 degrees of temperature under atmospheric conditions.

It is easily proved that about five and one-half times the heat units needed to produce the temperature are required, or 181 units per pound, because 5½ pounds of water can be raised to the point of ebullition, by adding 1 pound of 212 F. steam, showing that all the heat imparted to 1 pound of water to make it into 1 pound of steam can be given back, showing that nothing is lost and all is utilizable.

This point is pertinent, because it proves that you cannot get more than the steam gives; hence what becomes of the 10 to 12 per cent. of saving said to be obtained by using live-steam feed?

It is well known that an injector brings down the pressure. D. S. Jacobus has proved by direct experiment that feeding cold water directly into a boiler with a feed pump is not quite so economical as with an injector, whilst feeding through a heater by a pump is more economical than the injector.

With 1.0 as unity, then the relative values of feeding becomes as follows:

| | |
|---|---|
| Direct-acting pump, water at 60 F., without a heater | 1.000 |
| Injector feeding at 150 F. | .985 |
| Injector feeding with water taken through a heater, raised from 150 to 200 F. | .938 |
| Direct-acting pump, feeding through a heater, water from 60 to 200 F. | .879 |
| Geared pump, run from engine, in which the water is raised from 60 to 200 F. | .862 |

Taking them in their order, the efficiency relative is as follows: First, 1.0; second, 1.5; third, 6.8; fourth, 13.2.

From this it is seen that heating the feed water by the waste gases and pumping is the most economical; the steam for work being taken from the boiler it is feeding.

This brings in the question of "thermal storage." Assume the water to be raised to 200 F., of 170-unit value; then about 280 units are required per 1 pound of water, or 5½ pounds of water needs 1 pound of live steam approximately.

Any attempt to gravitate the feed from the storage to the generator by admitting full steam pressure into the storage must destroy circulation, and this is the life of steam making, and also of safety; hence gravitation methods should be discouraged.

A storage system needs two pumps, one to feed the storage and the other to feed the boiler and to force circulation.

It may be said that this is not live-steam feed, but it is when the storage is nearly the temperature of the steam in the boiler.

The actual economy factor of a live-steam feed plant is doubtful, but the advantages may be there, viz., equal temperature and forced circulation. One represents safety to the structure, and the other tends to a greater quantity of steam from a given size of boiler; therefore, live-steam feed heating is in the right direction.

In this sense the live-steam feed may be said to be economical, but to say that a boiler is 10 to 12 per cent. more economical of fuel by using live-steam feed is trying to prove that which is impossible.

# THE RELATIONS OF CHEMISTRY AND ENGINEERING

By John B. C. Kershaw

THE writer recently had some correspondence with one of the most notable and successful English electrical engineers of the present day upon the relations of chemistry and engineering, and in the course of this correspondence the latter expressed the opinion that the chief work of the industrial era which is now dawning will be carried out, not by chemists, and not by engineers, but by men who combine a working knowledge of both chemistry and engineering, who will as time passes on form a new profession of "chemical engineering."

This opinion, it may be admitted, is somewhat in advance of that generally held by engineers, and it is the writer's purpose in this article to examine the evidence which can be produced in support of it, from a study of the industries of the United Kingdom and the United States at the present time.

The industrial progress of the nineteenth century was, without doubt, chiefly due to the work of engineers. The discovery and development of the coal resources of England and America immediately followed the improvement of Watt's and Stephenson's steam engines. Mechanical power gradually replaced hand-power in all departments of manufacturing industry—the factory system became established, and was followed by an enormous increase in the scale of production, and by a corresponding diminution in the costs of manufacture. During all of this period of rapid progress it was the engineer who took the leading rôle and directed the operations.

The building of the main lines of railway which traverse the United Kingdom and the great continent of North America was also a work carried out by engineers during the middle and later years of the nineteenth century, while it is to the electrical engineers that we owe thanks for the improvements in the speed and comfort of suburban travel which have taken place during the last twenty-five years. The material and industrial progress of the nineteenth century from its dawn to its close was, in fact, dominated by the engineer, and the chemist, excepting in Germany, was relegated to an inferior and much more humble position.

What grounds are there, then, for asserting that the twentieth century is to witness some correction of this relationship, or for the belief that the material and industrial progress of the present century will be more largely due to the application of chemical principles and knowledge to the problems of the world of industry?

Is this a mere assumption, or can it be supported by facts drawn from the present conditions of industry in both the Old and New worlds?

For the purposes of this article and of the general argument which runs through it, it will be most useful to consider the facts under the headings into which the subject naturally divides itself.

### POWER GENERATION.

In the early days of the mid-Victorian epoch, when the factory system had only just established itself and the world's markets lay open to each manufacturer, there was little need to care for the economic aspect of power generation. The saving by the substitution of mechanical for hand-power was so great that a large market and huge profits were assured, and no manufacturer or factory owner bothered himself with the question whether his fuel was being utilized to the best advantage or with the efficiency of his boiler installation. The power costs might be high when considered in the light of present-day knowledge, but the price at which he sold his goods sufficed to cover this and to yield him large profits. To-day the position is changed. Not only has each manufacturer to meet a competition from rival manufacturers, both in his own and other countries, that grows more keen as the years pass on, but new and cheaper sources of power are being tapped and exploited. These render it imperative that the "power" item in each manufacturer's cost sheet should be reduced to the lowest possible figure if he is to maintain his position in the struggle.

It is here that the chemist has stepped in and has rendered great service to the engineer. By pointing out possible sources of loss in the steam-power plant, and also by suggesting methods of checking the working of these, which are more accurate than those used in the past, he has done something to raise the efficiency and to prolong the life of the steam-power plant, and of the manufacturer who depends upon it. No large steam-power plant of the present day, in fact, can be considered well-equipped unless it possesses a laboratory for the regular examination of fuel, feed-water and waste-gases; and the more attention there is paid to this work the greater is the efficiency and economy of the power plant. Savings in fuel ranging from 5 per cent. up to 15 per cent. and 20 per cent. have been recorded, resulting from this treatment of the problem of power-generation from coal as a chemical process, in which the aim is, first to obtain the highest possible amount of heat by the combustion of the fuel, and secondly to transfer this heat to the water with the minimum percentage of loss.

Turning to the other sources of power which have only been exploited within recent years (although with much energy and success) it may be admitted that the chemist has not much scope for the display of his abilities in the generation of power from water, and that here chemical knowledge and chemical principles are at a discount, excepting in regard to the choice of oils and lubricants for transformers and motors. When one turns, however, to the subject of gas power one is confronted by problems which are certainly mainly chemical in character. The design and operation of gas producers and gas engines demand chemical knowledge and an engineering chemist's supervision if the plant is to be successful.

The gas engine is already hailed as the prime mover of the near future, and since its thermal efficiency is approximately two and a half times that of the best steam engine the ousting of the latter is only a question of time. The conversion of a fuel into a gas of regular quality suitable for use in a large gas engine is, however, a more difficult operation and process than its complete combustion in the furnace of a steam boiler, and chemical engineers will be required to take charge of all producer gas installations designed for power generation on a large scale.

Even in the utilization of poor fuels, like peat, the chemist and chemical engineer will have an important rôle to fill, for the only processes of peat utilization which seem to hold the seeds of success depend upon the gasification of the peat and the recovery of the tar and other by-products, including the nitrogen as ammonia. The power-gas plant of the future will, in fact, in many cases resemble a small chemical works, and the production of the gas will be but the first and most unimportant step in a whole series of chemical operations and processes. Chemists and chemical engineers will thus have a great future before them in this branch of power generation.

### MANUFACTURING OPERATIONS.

The smelting of iron and manufacture of steel is one of the oldest and most important of the world's industries, and in this industry the engineer with the training of a metallurgical chemist or metallurgist is rapidly increasing in importance. One of the most remarkable and far-reaching discoveries of the last twenty-five years has related to the influence of small amounts of such metals as nickel manganese, chromium, tungsten and vanadium upon the physical properties of the finished steel. The manufacture of armour plates and of the high-speel tool-steels is now a most important branch of the steel industry, and this branch of manufacture is only rendered possible by the careful work of the steel works chemist and metallurgist. It is, in fact, now believed that the high qualities of the best Swedish steel and the remarkable properties of the sword blades made in Damascus and Toledo hundreds of years ago have been due to the presence of some of these rare metals in the original ore from which the steel was made. The metallurgist is thus repeating to-day, by more scientific methods, the chance mixings which produced the wonderful sword steels of an age long gone by.

The electric furnace has placed in the hands of the steel manufacturer a whole series of alloys of the rare metals with iron which were unobtainable ten or fiften years ago; and in the manufacture and utilization of these alloys the metallurgical chemist must necessarily fill an important rôle.

The chemical side of iron and steel manufacture is thus becoming of greater importance in the successful conduct of this large and most important industry, and no steel maker of the present day can afford to remain ignorant of the chemical and metallurgical principles underlying the manufacture.

The manufacture of Portland cement is another of the world's large industries that is rapidly growing, and in which the importance of the chemist and chemical engineer cannot be overemphasized. The modern method of building construction in which reinforced concrete has displaced brick and stone has led to an enormously increased demand for Portland cement, and the safety of many of our largest modern buildings is thus dependent upon the quality of the concrete used in their construction. But the quality of Portland cement is a matter of care and attention to the selection, grinding and mixing of the raw materials from which it is made, and here again the chemical engineer is the man who controls the processes and determines the success or otherwise of the manufacture.

Gold extraction is another example of an old-established and important industry which has now entered upon a phase in which the chemist is of equal, if not of greater, importance than the engineer. Since the introduction of the cyanide process of gold extraction, by means of which enormous reserves and waste heaps of gold-bearing sand or "tailings" have been treated and the gold extracted with a minimum of cost, new gold-bearing districts have been developed and the gold output of the world has been trebled. The cyanide process is, however, essentially chemical or electro-chemical in character, and no cyanide plant can be worked without a staff of skilled metallurgical chemists to control it.

The simple mechanical process of gold recovery by washing has, in fact, been displaced by a chemical process of extraction, and a cyanide plant is really a chemical works in which gold is extracted from the tailings with a suitable solvent, and is then deposited from the solution by chemical substitution of another metal—namely, lead or zinc.

The extraction or separation of other metals from their ores by similar methods is also extending, and a knowledge of chemistry is thus becoming more and more imperative for those who have control of smelting operations. In many cases ores contain small amounts of rarer metals of high value, which can be recovered with large profits, if the attempt is made by men possessing the requisite engineering and chemical knowledge. The separation of the rare earths from the monazite sands of Brazil is another large and important industry in which chemical methods play the leading part, and is at present entirely in the hands of German firms. The dump heap of some old-established mine is now often found to be of greater value than the mine itself.

### UTILIZATION OF WASTE PRODUCTS.

The twentieth century will, no doubt, be marked in the history of the world's manufacturing industries by the success of the efforts made to utilize "waste products," and in this field of activity the chemist or chemical engineer will again take the leading rôle. Power from the waste gases of blast furnaces is already generated upon a large scale, both on the Continent and in this country. There is little reason to doubt that, as time passes on, this hitherto wasted source of energy will be more and more utilized for various purposes. But the design and control of large gas engines of 1,000 horse-power and operating with blast-furnace gas demand chemical knowledge, and any larger installation of this kind can only be erected and run with success by men possessing both a chemical and engineering training. Gas analysis will, in fact, form a regular feature in the operation of any large plant for generating power from blast-furnace gases, and the man in charge must be able to interpret the results obtained rightly if the highest economy is to be attained.

Waste products containing combustible matter are now burned in special forms of furnace or are utilized in gas producers, in order to recover the heat value of the combustible, and here again chemical and engineering knowledge is required in order to design and work the furnaces or producers with the maximum of efficiency. Refuse destructors also demand similar qualification in those who design and control them.

The manufacture of useful products from the slag of blast furnaces and from the clinker of furnaces and destructors is another branch of modern industry that is growing rapidly in importance and in which large profits can be made.

It was the chemist who first pointed out the value to the agriculturalist of the phosphorus contained in ground Thomas slag; the manufacture of ground slag is now an important sub-branch of the iron and steel industry.

The manufacture of artificial stone and of building slabs, from the clinker of destructors and other similar types of furnace, is also a growing industry, and one in which a knowledge of both chemistry and engineering is demanded.

The treatment of sewage is another example of a large and important public service, which is now largely controlled by the chemist or chemical engineer. The collection and pumping of sewage is no longer the end of the story, but is merely the preliminary to some form of treatment. It is no longer thought wise or beneficial, in fact, to turn sewage in its raw state into the nearest river or river estuary, and the bacterial treatment of sewage has now been generally accepted as the best and most efficient system of purification.

Most of the larger English towns and cities which care for sanitation have erected bacterial tanks and filter beds, and are increasing their equipment of these. But the bacterial treatment of sewage is really a chemical operation, in which living organisms are carrying out the chemical changes required to produce a harmless effluent, and if the highest success is to be achieved chemical engineers are again required to design and take charge of these installations.

Limits of space will not allow the writer to discuss in an equally detailed manner those manufacturing industries in which a more extensive knowledge of chemistry is of supreme importance for those who are in positions of authority. The aniline colour industry is perhaps the most notable example of a large industry created by the labours of the chemist in his laboratory. Other manufactures similar in character are those of artificial indigo, madder, silk, rubber, leather, wood and ivory, and last, but not least, that of artificial nitrates from the air. The manufacture of explosives is also becoming more and more chemical in character.

In all these manufactures engineering and chemical knowledge must be combined in order to obtain the best results, and it would be difficult for either an engineer or chemist alone to overcome all the difficulties met with.

Sufficient, however, has been said to show the importance of chemical knowledge for the practical engineers who are to control the manufacturing industries of the twentieth century, and to substantiate the claim that chemical engineering will be one of the most important professions of the coming industrial era.

The subject of this article and the plea for a closer co-operation between chemists and engineers is therefore one which should receive earnest attention from all readers of Cassier's Magazine. In a later issue the writer hopes to present some further remarks upon its significance for present-day engineers, and to indicate what, in his opinion, would be the best form of training for men who aspire to enter the ranks of this new profession.

# FUTURE SOURCES OF MOTIVE POWER

By Sir William Ramsay, F. R. S., etc.

ABSTRACT FROM PRESIDENTIAL ADDRESS BEFORE THE BRITISH ASSOCIATION

In his Presidential address before the late meeting of the British Association for the Advancement of Science, Sir William Ramsay discusses certain engineering problems which demand close and earnest attention. That some other source of motive power will be developed to meet the loss due to the waning coal supply is generally conceded, but we are in little better position to predict its exact nature at the present time than were such men as Newton, Wallis or Wren in the latter part of the seventeenth century. In connection with the statements of Professor Ramsay concerning man power, it will be interesting to compare the article of Mr. Greenfield, elsewhere in this issue.—The Editor.

IT has been the usual custom of my predecessors in office either to give a summary of the progress of science within the past year or to attempt to present in intelligible language some aspect of the science in which they have themselves been engaged. I possess no qualifications for the former course, and I therefore ask you to bear with me while I devote some minutes to the consideration of ancient and modern views regarding the chemical elements.

It is difficult to say when the first element was known to be an element. After Lavoisier's overthrow of the phlogistic hypothesis, the part played by oxygen, then recently discovered by Priestly and Scheele, came prominently forward. Loss of phlogiston was identified with oxidation; gain of phlogiston, with loss of oxygen. The scheme of nomenclature ("Méthode de Nomenclature chimique"), published by Lavoisier in conjunction with Guyton de Morveau, Berthollet, and Fourcroy, created a system of chemistry out of a wilderness of isolated facts and descriptions.

The modern conception of the elements was much strengthened by Dalton's revival of the Greek hypothesis of the atomic constitution of matter, and the assigning to each atom a definite weight. This momentous step for the progress of chemistry was taken in 1803; the first account of the theory was given to the public with Dalton's consent in the third edition of Thomas Thomson's "System of Chemistry" in 1807; it was subsequently elaborated in the first volume of Dalton's own "System of Chemical Philosophy," published in 1808. The notion that compounds consisted of aggregations of atoms of elements, united in definite or multiple proportions, familiarized the world with the conception of elements as the bricks of which the universe is built. Yet the more daring spirits of that day were not without hope that the elements themselves might prove decomposable.

Indeed, the ancient idea of the unitary nature of matter was in those days held to be highly probable, for attempts were soon made to demonstrate that the atomic weights were themselves multiples of that of one of the elements.

The relation between the elements has, however, been approached from another point of view. After preliminary suggestions by Döbereiner, Dumas, and others, John Newlands, in 1862 and the following years, arranged the elements in the numerical order of their atomic weights, and published in the *Chemical News* of 1863 what he termed his law of octaves—that every eighth element, like the octave of a musical note, is in some measure a repetition of its forerunner. The same fundamental notion was reproduced at a later date and independently by Lothar Meyer and Dmitri Mendeléeff.

Including the inactive gases, and adding the more recently discovered elements of the rare earths, and radium, of which I shall have more to say presently, there are eighty-four definite elements, all of which find places in the periodic table, if merely numerical values be considered. Between lanthanum, with atomic weight 139, and tantalum, 181, there are in the periodic table seventeen spaces; and although it is impossible to admit, on account of their properties, that the elements of the rare earths can be distributed in successive columns—for they all resemble lanthanum in properties—yet there are now fourteen such elements; and it is not improbable that other three will be separated from the complex mixtures of their oxides by further work. Assuming that the metals of the rare earths fill these seventeen spaces, how many still remain to be filled? We will take it for granted that the atomic weight of uranium, 238.5, which is the highest known, forms an upper limit not likely to be surpassed. It is easy to count the gaps; there are eleven.

But we are confronted by an *embarras de richesse*. The discovery of radioactivity by Henri Becquerel, of radium by the Curies, and the theory of the disintegration of the radioactive elements, which we owe to Rutherford and Soddy, have indicated the existence of no fewer than twenty-six elements hitherto unknown. To what places in the periodic table can they be assigned?

Of these twenty-six elements derived from uranium, thorium, and actinium, ten, which are formed by the emission of electrons alone, may be regarded as allotropes or pseudo-elements; this leaves sixteen, for which sixteen or seventeen gaps would appear to be available in the periodic table, provided the reasonable supposition be made that a second change in the length of the periods has taken place. It is, above all things, certain that it would be a fatal mistake to regard the existence of such elements as irreconcilable with the periodic arrangement, which has rendered to systematic chemistry such signal service in the past.

Attention has repeatedly been drawn to the enormous quantity of energy stored up in radium and its descendants—that in its emanation, niton is such that if what it parts with as heat during its disintegration were available it would be equal to three and a half million times the energy available by the explosion of an equal volume of detonating gas—a mixture of one volume of oxygen with two volumes of hydrogen. The major part of this energy comes, apparently, from the expulsion of particles (that is, of atoms of helium) with enormous velocity. It is easy to convey an idea of this magnitude in a form more realizable, by giving it a somewhat mechanical turn. Suppose that the energy in a ton of radium could be utilized in thirty years, instead of being evolved at its invariably slow rate of 1,760 years for half disintegration, it would suffice to propel a ship of 15,000 tons, with engines of 15,000 horse-power, at the rate of 15 knots an hour, for thirty years—practically the lifetime of the ship. To do this actually requires a million and a half tons of coal.

It is easily seen that the virtue of the energy of the radium consists in the small weight in which it is contained; in other words, the radium-energy is in an enormously concentrated form. I have attempted to apply the energy contained in niton to various purposes; it decomposes water, ammonia, hydrogen chloride, and carbon dioxide, each into its constituents; further experiments on its action on salts of copper appeared to show that the metal copper was converted partially into lithium, a metal of the sodium column; and similar experiments, of which there is not time to speak, indicate that thorium, zirconium, titanium and silicon are degraded into carbon; for solutions of compounds of these, mixed with niton, invariably generated carbon dioxide, while cerium, silver, mercury, and some other metals gave none. One can imagine the very atoms themselves, exposed to bombardment by enormously quickly moving helium atoms, failing to withstand the impacts. Indeed, the argument *a priori* is a strong one; if we know for certain that radium and its descendants decompose spontaneously, evolving energy, why should not other more stable elements decompose when subjected to enormous strains?

This leads to the speculation whether, if elements are capable of disintegration, the world may not have at its disposal a hitherto unsuspected source of energy. If radium were to evolve its stored-up energy at the same rate that gun-cotton does, we should have an undreamt-of explosive; could we control the rate we should have a useful and potent source of energy, provided always that a sufficient supply of radium were forthcoming. But the supply is certainly a very limited one; and it can be safely affirmed that the production will never surpass half an ounce a year. If, however, the elements which we have been used to consider as permanent are capable of changing with evolution of energy, if some form of catalyser could be discovered which would usefully increase their almost inconceivably slow rate of change, then it is not too much to say that the whole future of our race would be altered.

The middle of the nineteenth century will always be noted as the beginning of the golden age of science, the epoch when great generalizations were made of the highest importance on all sides—philosophical, economic, and scientific. Carnot, Clausius, Helmholtz, Julius Robert Mayer abroad, and the Thomsons (Lord Kelvin and his brother James), Rankine, Tait, Joule, Clerk Maxwell and many others at home, laid the foundations on which the splendid structure has been erected. That the latent energy of fuel can be converted into energy of motion by means of the steam engine is what we owe to Newcomen and Watt, that the kinetic energy of the flywheel can be transformed into electrical energy was due to Faraday, and to him, too, we are indebted for the re-conversion of electrical energy into mechanical work; and it is this power of work which gives us leisure, and which enables a small country like ours to support the population which inhabits it.

I suppose that it will be generally granted that the Commonwealth of Athens attained a high-water mark in literature and thought which has never yet been surpassed. The reason is not difficult to find; a large proportion of its people had ample leisure, due to ample means; they had time to think, and time to discuss what they thought. How was this achieved? The answer is simple: Each Greek Freeman had on an average at least five helots who did his bidding, who worked his mines, looked after his farm, and, in short, saved him from manual labour. Now, we in Britain are much better off; the population of the British Isles is, in round numbers, 45 millions; there are consumed in our factories at least 50 million tons of coal annually, and "it is generally agreed that the consumption of coal per indicated horse-power per hour is on an average about 5 pounds." (Royal Commission on Coal Supplies, Part I.) This gives seven million horse-power per year. How many man-power are equal to a horse-power? I have arrived at an estimate thus: A Bhutanese can carry 230 pounds plus his own weight, in all 400 pounds, up a hill 4,000 feet high in eight hours; this is equivalent to about one twenty-fifth of a horse-power; seven million horse-power are therefore about 175 million-man power. Taking a family as consisting on the average of five persons, our 45 millions would represent nine million families; and dividing the total man-power by the number of families, we must conclude that each British family has on the average nearly twenty "helots" doing his bidding, instead of the five of the

Athenian family. We do not appear, however, to have gained more leisure thereby, but it is this that makes it possible for the British Isles to support the population which it does.

We have in this world of ours only a limited supply of stored-up energy; in the British Isles a very limited one—namely, our coal fields. The rate at which this supply is being exhausted has been increasing very steadily for the last forty years, as any one can prove by mapping the data given on page 27, Table D, of the General Report of the Royal Commission on Coal Supplies (1906). In 1870, 110 million tons were mined in Great Britain, and ever since the amount has increased by $3\frac{1}{3}$ million tons a year. The available quantity of coal in the proved coal fields is very nearly 100,000 million tons; it is easy to calculate that if the rate of working increases as it is doing our coal will be completely exhausted in 175 years. But, it will be replied, the rate of increase will slow down. Why? It has shown no sign whatever of slackening during the last forty years. Later, of course, it must slow down, when coal grows dearer owing to approaching exhaustion. It may also be said that 175 years is a long time; why, I myself have seen a man whose father fought in the '45 on the Pretender's side, nearly 170 years ago! In the life of a nation 175 years is a span.

This consumption is still proceeding at an accelerated rate. Betwen 1905 and 1907 the amount of coal raised in the United Kingdom increased from 236 to 268 million tons, equal to 6 tons per head of the population, against 3½ tons in Belgium, 2½ tons in Germany, and 1 ton in France. Our commercial supremacy and our power of competing with other European nations are obviously governed, so far as we can see, by the relative price of coal; and when our prices rise, owing to the approaching exhaustion of our supplies, we may look forward to the near approach of famine and misery.

Various schemes have been proposed for utilizing our deposits of peat. I believe that in Germany the peat industry is moderately profitable; but our humid climate does not lend itself to natural evaporation of most of the large amount of water contained in peat, without which processes of distillation prove barely remunerative.

We must therefore rely chiefly on our coal reserve for our supply of energy, and for the means of supporting our population; and it is to the more economical use of coal that we must look, in order that our life as a nation may be prolonged. We can economize in many ways: By the substitution of turbine engines for reciprocating engines, thereby reducing the coal required per horse-power from 4 pounds to 5 pounds to 1½ pounds to 2 pounds; by the further replacement of turbines by gas engines, raising the economy to 30 per cent. of the total energy available in the coal, that is, lowering the coal consumption per horse-power to 1 pounds or 1¼ pound; by creating the power at the pit mouth, and distributing it electrically, as is already done in the Tyne district. Economy can also be effected in replacing "beehive" coke ovens by recovery ovens; this is rapidly being done; and Dr. Beilby calculates that in 1909 nearly six million tons of coal, out of a total of sixteen to eighteen millions, were coked in recovery ovens, thus effecting a saving of two to three million tons of fuel annually. Progress is also being made in substituting gas for coal or coke in metallurgical, chemical and other works. But it must be remembered that for economic use, gaseous fuel must not be charged with the heavy costs of piping and distribution.

The domestic fire problem is also one which claims our instant attention. It is best grappled with from the point of view of smoke. Although the actual loss of thermal energy in the form of smoke is small—at most less than ½ per cent. of the fuel consumed—still the presence of smoke is a sign of waste of fuel and careless stoking. In works, mechanical stokers which insure regularity of firing and complete combustion of fuel are more and more widely replacing hand-firing. But we are still utterly wasteful in our consumption of fuel in domestic fires. There is probably no single remedy applicable; but the introduction of central heating, of gas fires, and of grates which permit of better utilization of fuel will all play a part in economizing our coal. It is open to argument whether it might not be wise to hasten the time when smoke is no more by imposing a sixpenny fine for each offense; an instantaneous photograph could easily prove the offense to have been committed; and the imposition of the fine might be delayed until three warnings had been given by the police.

Now, I think that what I wish to convey will be best expressed by an allegory. A man of mature years who has surmounted the troubles of childhood and adolescence without much disturbance to his physical and mental state, gradually becomes aware that he is suffering from loss of blood; his system is being drained of this essential to life and strength. What does he do? If he is sensible he calls in a doctor, or perhaps several, in consultation; they ascertain the seat of the disease, and diagnose the cause. They point out that while consumption of blood is necessary for healthy life, it will lead to a premature end if the constantly increasing drain is not stopped. They suggest certain precautionary measures; and if he adopts them he has a good chance of living at least as long as his contemporaries; if he neglects them his days are numbered.

That is our condition as a nation. We have had our consultation in 1903; the doctors were the members of the Coal Commission. They showed the gravity of our case, but we have turned a deaf ear.

It is true that the self-interest of coal consumers is slowly leading them to adopt more economical means of turning coal into energy. But I have noticed and frequently publicly announced a fact which cannot but strike even the most unobservant. It is this: When trade is good, as it appears to be at present, manufacturers are making money, they are overwhelmed with orders, and have no inclination to adopt economies which do not appear to them to be essential, and the introduction of which would take thought and time, and which would withdraw the attention of their employees from the chief object of the business—how to make the most of the present opportunities. Hence improvements are postponed. When bad times come, then there is no money to spend on improvements; they are again postponed until better times arrive.

What can be done?

I would answer: Do as other nations have done and are doing; take stock annually. The Americans have a permanent commission initiated by Mr. Roosevelt, consisting of three representatives from each State, the sole object of which is to keep abreast with the diminution of the stores of natural energy, and to take steps to lessen its rate. This is a non-political undertaking, and one worthy of being initiated by the ruler of a great country. If the example is followed here the question will become a national one.

Two courses are open to us: First, the *laissez-faire* plan of leaving to self-interested competition the combating of waste; or secondly, initiating legislation which, in the interest of the whole nation, will endeavour to lessen the squandering of our national resources. This legislation may be of two kinds—penal, that is, imposing a penalty on wasteful expenditure of energy supplies; and helpful, that is, imparting information as to what can be done, advancing loans at an easy rate of interest to enable reforms to be carried out, and insisting on the greater prosperity which would result from the use of more efficient appliances.

This is not the place, nor is there the time, to enter into detail; the subject is a complicated one, and it will demand the combined efforts of experts and legislators for a generation; but if it be not considered with the definite intention of immediate action, we shall be held up to the deserved execration of our not very remote descendants.

The two great principles which I have alluded to in an earlier part of this address must not, however, be lost sight of; they should guide all our efforts to use energy economically. Concentration of energy in the form of electric current at high potential makes it possible to convey it for long distances through thin and, therefore, comparatively inexpensive wires; and the economic coefficient of the conversion of mechanical into electrical, and of electrical into mechanical energy is a high one; the useless expenditure does not much exceed one-twentieth part of the energy which can be utilized. These considerations would point to the conversion at the pit mouth of the energy of the fuel into electrical energy, using as an intermediary turbines, or preferably gas engines, and distributing the electrical energy to where it is wanted. The use of gas engines may, if desired, be accompanied by the production of half-distilled coal, a fuel which burns nearly without smoke, and one which is suitable for domestic fires, if it is found too difficult to displace them and to induce our population to adopt the more efficient and economical systems of domestic heating which are used in America and on the Continent. The increasing use of gas for factory, metallurgical and chemical purposes points to the gradual concentration of works near the coal mines, in order that the laying down of expensive piping may be avoided.

An invention which would enable us to convert the energy of coal directly into electrical energy would revolutionize our ideas and methods, yet it is not unthinkable. The nearest practical approach to this is the Mond gas battery, which, however, has not succeeded, owing to the imperfection of the machine.

In conclusion, I would put in a plea for the study of pure science, without regard to its application. The discovery of radium and similar radioactive substances has widened the bounds of thought. While themselves, in all probability, incapable of industrial application, save in the domain of medicine, their study has shown us what enormous advances in the concentration of energy it is permissible to look forward, with the hope of applying the knowledge thereby gained to the betterment of the whole human race.

As charity begins at home, however, and as I am speaking to the British Association for the Advancement of Science, I would urge that our first duty is to strive for all which makes for the permanence of the British Commonweal, and which will enable us to transmit to our posterity a heritage not unworthy to be added to that which we have received from those who have gone before.

# MODERN HAULING PROBLEMS

By Rollin W. Hutchinson

THIS is a day of modernizing in every industry, profession and business. Indeed, as it was aptly expressed by an engineer in the discussion of a paper by a member of a technical body a few weeks since on scientific management in business —"America has gone modernizing mad." Unfortunately, the incubus of modernizing has only begun to inoculate the business world with a desire to shake off the lethargy which custom and habit have long affected it with respect to its individual merchandise transportation problems. (In this country we have so long depended upon the horse and the "old mule" as the purveyors of commodities of commerce to our customers or to and from the warehouses of our common carriers that we have not yet awakened to the fact that for a large number of conditions in haulage work the horse is an anachronistic animal.

The horse and mule—noble servitors of mankind—have been with us so long that naturally these animals have become standard units of measure in our haulage problems. We are accustomed to compare any other type of haulage agent on the basis of "Is it better than a horse?" just as we speak in weights and distances, and for an answer we only get a guess if we have not equated the horse standard to specific cost and definite time. Minutes or hours and dollars in all businesses should be our measuring rules of efficiency and conservation. Just as the new science of scientific management recognizes labour as a commodity, so likewise we must surely give transportation its true value as a *commodity*.

In considering the advantages which the auto-truck or delivery wagon can confer to any business or industry, we must remember that an analysis must be made of one's transportation problems to determine whether the disestablishing of the mule and horse system will make for greater efficiency and economy in time and dollars. Unless the power truck will save one money in the end or protect one's custom better than otherwise it is unwise to adopt it. In the future the benefits which the power wagon will confer to many industries and businesses will be recognized by the business world as being broader than the mere saving in dollars and cents and time. The advantages of the power truck used in its proper sphere are broader than the utilitation advantages of efficiency, economy, quickness in covering distances, etc., which the motor truck possesses by an overwhelming majority over the horse-drawn truck. There are larger social, sanitary and humanitarian reasons which make the ultimate displacement of the animal for heavy haulage work by business firms inevitable. It is not so much a question of the greater economy of the power truck, which is admitted by all who have applied the modern methods of cost accounting to their horse and power trucks, but it is a problem of evolution in human progress, as it were, paralleling in causes the supplanting of the horse street car by the electric car on account of the greater speed and the longer radius of transportation possible with the latter. Likewise will the horse truck have to give way to the motor truck, aside from any question of greater economy in transportation which the latter effects. Until, however, the power truck is given its full measure of appreciation along the lines above discussed we must apply our dollars-and-time measuring rule when considering the subject of substituting the auto-truck for the animal truck.

Every business man having draying or the moving of material or the delivery of goods should inform himself what a power truck will do for him. The motor truck is not for the man who has work for but one horse or for two horses, because they as two units are better in many instances than one motor truck, but that is a problem for you to be sure about before you buy. Every business man or firm that is now using several horses as an experiment in his business with a motor truck which has been purchased on the same basis as any other high-class machine is purchased—a careful investigation of the reputation of the maker and the service which his product has given other firms having haulage problems.

Undoubtedly the biggest obstacle to proper consideration of the installation of the auto-truck in solving haulage problems is the fact that very few concerns which have use for many horse-drawn vehicles have even a crude cost system upon that part of their business. They are content to lump their haulage or stable expenses at so much cost—generally an arbitrary figure guessed by their stable boss or traffic man with the aid of the bookkeeper. This arbitrary fixed "necessary" outlay to do the transportation business has thus prevented the logical users of power trucks from comparing the utility of an auto-truck in the haulage end of their business. Wherever the actual and not theoretical cost of animal and power-truck haulage is *known and not assumed* the power truck *has remained,* and has in the majority of instances *multiplied.* It must be remembered, however, that unless the haulage work required of an auto-truck is sufficient to keep it constantly in service at approximately its rated local capacity that its maximum efficiency as a transportation machine can not be gained. Long hauls with reasonably big loads (but not overloads) are the fields of action in which the gasoline auto-truck glories. A high-grade auto-truck of 7 tons load capacity will cost, for instance, from $5,000 to $6,500 equipped with a special body for carrying a bulky load, like baled cotton or baled manufactured goods. An analysis of the investment and the operating charges for a 6½-ton truck based on the experience of a large foundry company which makes heavy castings to a very large extent showed the following figures:

INVESTMENT

| | | |
|---|---|---|
| 6½-ton truck (with extra large body) | | $6,500.00 |
| Number of days operated per year. | 300 | |
| Number of miles operated per day. | 40 | |
| Total miles per year | 12,000 | |

OPERATING EXPENSES

| | |
|---|---|
| Interest on I6,500 at 5 per cent | $325.00 |
| Depreciation at 5 cents per mile | 600.00 |
| Maintenance at 5 cents per mile | 600.00 |
| Tires at 8 cents per mile (guaranteed) | 960.00 |
| Gasoline at 11 cents per gallon | 12.75 |
| Oil at 40 cents per gallon | 15.00 |
| Grease | 12.50 |
| Insurance | 250.00 |
| Driver at $20 per week | 1,040.00 |
| Garage charges, washing, etc | 275.00 |
| Total cost per year | 4,090.25 |
| Total cost per day | 13,63 |
| Total cost per mile | .34 |
| Total cost per ton-mile | .075 |

This analysis is based on a large foundry manufacturing company's experience, which has to deliver to and from stations its products, and to and from customers in cities, and the figures apply to a make of truck which is perhaps the highest priced on the market, but which is claimed to be the cheapest in operating cost. In presenting these figures the writer has chosen for illustration a machine which has been on the market for ten years, and which is conceded by truck experts to be one of the highest deevlopments of the freight automobile manufactured. It should be remembered that, while the initial investment for a power truck of the type mentioned is apparently large, it is not first cost, but *operating cost,* that should be the principal consideration in the purchase of a business vehicle. The truck industry in America is a young institution, and only a relatively small number of makers have been producing auto-trucks for a period of five years. It is unsafe to buy a truck which has not had a commercial development of at least five years, as truck manufacturers have only within this period begun to understand that a pleasure automobile chassis fitted with an express body is a mechanical abortion unfitted for real business service.

Naturally, the first question the prospective purchaser of a motor truck wants to know is "How much will it cost to run?" to which question no honest salesman of a truck can answer more intelligently than "It all depends." It is regrettably true that there is no really satisfactory or equable basis which enables the performance of any motor truck to be compared with that of any other motor truck, but a thoughtful analysis will prove this to be a fact. If two firms have two or more trucks of the same make and model and use them under precisely the same conditions, it is feasible to compare the operation of the machines in every detail. Similarly, two competitive firms with places of business abutting one another may operate auto-trucks of equal load capacity and of the same make to deliver goods to customers in the same locality. When this is the case it is not difficult to ascertain whether one truck is being worked more advantageously than the other simply on the matter of their respective operating costs and performance. A few limited conditions, such as the examples cited, only obtain to enable a cost comparison to be made that will be reasonably satisfactory. Although cost analysis and accounting of high exactitude have been applied to modern business methods, motor-truck haulage is a business which at this time does not permit of reliable cost analysis. Cost data on auto-truck haulage are apt to be badly misleading.

Every performance of an auto-truck is individual. Figures on operating cost of power trucks for similar classes of haulage are vitiated by one or more of the following causes: differences in the facilities and method employed in garaging, wide differences in road conditions and the grades encountered, wide variations in the kinds of roads to operate over at different periods by the same truck, differences in speeds and the very important matter of the character of driver employed. The personal equation, which means the peculiar capacity of every driver to overload or abuse his machine, affects figures purporting to give the cost per ton-mile of truck-haulage most appreciably. It is simple to calculate the total weight of merchandise hauled by an auto-truck in a specific time, as well as the total distance made. On first thought, it would also seem easy enough to divide the product so obtained by the aggregate maintenance and upkeep costs to get the cost of haulage per ton-mile. These competitions are nugatory, however, for the following reasons: The assumption is that every mile run by the truck was traveled under uniform load; but, as an actual fact, half of the mileage may be traveled under no load at all. Again, in some cases the productive mileage may be traveled under a tapering or changing load, as, for example, when the truck of the textile manufacturer must take its rated cargo from two or more warehouses separated by considerable distances, or must deliver portions of its cargo of manufactured goods to several freight forwarding stations, the load decreasing as deliveries are being made. However, there are a number of conditions in the haulage work of the metal manufacturer where ideal loading conditions exist—i. e., where full loads are hauled in both directions and the truck is never run without its rated load. In these cases, maintenance and upkeep cost data on power trucks for drayage in the metal industry may be accepted by a company as reasonable criteria of what the displacement of animal teams for auto-trucks would accomplish in the betterment of their own business. But here, again, the influence of the personal equation (the driver), wide dissimilarity in road conditions, difference in character of construction of truck, etc., will prevent these cost data from one concern's truck-drayage experience from being anything more than a rough guide to a company contemplating the disestablishing of animal teams for power wagons.

Dependable data on auto-truck operating expenses are in as much need by motor truck manufacturers as they are by the individual who is keenly desirous of checking his own drayage data against standard data. Present conditions do not permit this being done, and will not until all the attendant circumstances are known. Hence, records which purport to give actual performances of some company's business motor vehicles should not be accepted as bases which can be duplicated in establishing one's own truck delivery system. Such records may be materially bettered, on the contrary, by each individual company's peculiar and individual factors and conditions. When a proper understanding of motor truck cost-keeping becomes general and properly verified, individual records are analyzed intelligently, and the truck manufacturers and owners will consent to put before the public all records, good and bad, for every kind of haulage, figures will be worth something to prospective truck investors. This statement should not be construed as throwing cold water on the economy of power wagon haulage. On the contrary, the writer has not heard of any case where power trucks were intelligently selected for any kind of haulage work, both with respect to the size of the units and the reliability of the maker's product, and even a rough bookkeeping system of accounting kept, that the user ever went back to horse drayage. Several years ago, before American truck makers had any real experience in power vehicle making or understood what strenuous service a commercial motor car would be put to, trucks were purchased without an intelligent understanding of the individual requirements and on the ill-advised judgment of pleasure automobile salesmen. These trucks were frequently of experimental designs, or else hybrids of pleasure-car construction, unadapted to real business service. In the hands of incompetent, abusive drivers they were hastened to their untimely ends in the junk shop. Naturally, the experiences of the business public which invested in these crude experimental machines were so disastrous that the truck industry received a severe backset. But the day when any progressive manufacturer or wholesaler should be suspicious of the reliability, wearing qualities and incomparably greater economy of the power over the animal-drawn truck has long passed. True, there are some makers of power trucks who have embarked into that industry without either the capital, organization or experience to produce a dependable product. Their designs have been copied from the reliable truck makers' products in a number of instances, and have not withstood the test of time—the only really safe criterion on which to buy a commercial motor car. On the other hand, there are a number of makes of power trucks which are as safe to invest in with certainty of service as a Baldwin locomotive or a Westinghouse air brake. It must be borne in mind that metals and mechanism have their limitations, as do human beings.

Overloading and over-speeding are the greatest drawbacks to the proper advance of the power truck in modernizing haulage systems. Regardless of what material a truck may be constructed, overloads and over-speeding will soon run up its maintenance and operating cost excessively. There is no class or kind of self-propelled vehicle which receives the strains, the abuse and neglect that the average power truck does. In general, the trucks that now fail are those that have been neglected. And the worse thing is that it is so unnecessary to do this. The locomotive, for instance, our oldest self-propelled vehicle, and hence the highest developed, is protected from shocks to its internals by running on steel rails and scientifically constructed roadbeds. It is only expected to run some 300 miles before going to the roundhouse, where it is cooled off, inspected critically for injuries or defects in its machinery. It must be in approximately perfect condition before it is put on another run. The power truck, on the other hand, is just in charge of an ex-teamster, without knowledge of machinery, who is entrusted with the care of a high-class business machine with only the crudest conception of his duties. No business man would think of putting a green teamster in charge of the electrical and mechanical apparatus of his power plant; yet it is just as consistent to put an inexperienced teamster in charge of a *road locomotive,* which is really what an auto-truck is.

In considering the purchase of a power truck this is what one is stepping into. The really reputable truck manufacturer does not want to sell a man a motor wagon unless he is really sure that the machine will protect the man's trade and save him money, and unless the buyer, in turn, is willing to take care of his investment, no self-respecting maker will care to sell him a truck and be subjected to unreasonable demands for replacements of parts which are in no wise his fault. Mileage does not hurt a truck, but overloading and over-speeding will break its back. If one can get more mileage out of his truck than his competitor, his truck will cost him less, irrespective of the first cost. It is not first cost which the sensible buyer looks at in investing in a power truck. Lasting qualities, low cost of maintenance and operation are, or should be, the determining criteria in buying a commercial motor car. One should not invest in a power truck without knowing his requirements. Some concerns will buy a 1½-ton truck when they really need a 3-ton truck, but they will expect the 1½-ton truck to do the duty of a 3-ton car by overloading it to its last limit. If the badly abused car begins to need hospital attention after a few months' usage, the purchaser oftentimes believes that he has a "come-back" on the maker of the truck. This is manifestly unfair. Even the finest steels, the most carefully designed and constructed mechanism, has its limitations. Abuse will kill the serviceability of any piece of machinery, whether it be steam locomotives, electric generators or power trucks. Unlike the horse, the power truck needs no rest. It will work twenty-four hours per day if you want it to, and its operating cost ceases when it is not on duty. But a truck, like a locomotive, deserves and should have roundhouse duty from a machine, if its useful life and satisfaction to its user are to be conserved. To get the ton-mileage out of a truck, which is the thing that reimburses you, you must do something more than merely sign your name to a check, fill the gasoline and oil tanks, put water in the radiator (or charge the batteries with electric current) and turn on the power.

A truck intelligently selected can always be made to pay, but its purchase will often necessitate a rearrangement of the customs and habits which now obtain with respect to horse haulage.

# THE PURIFICATION OF BOILER FEED-WATER

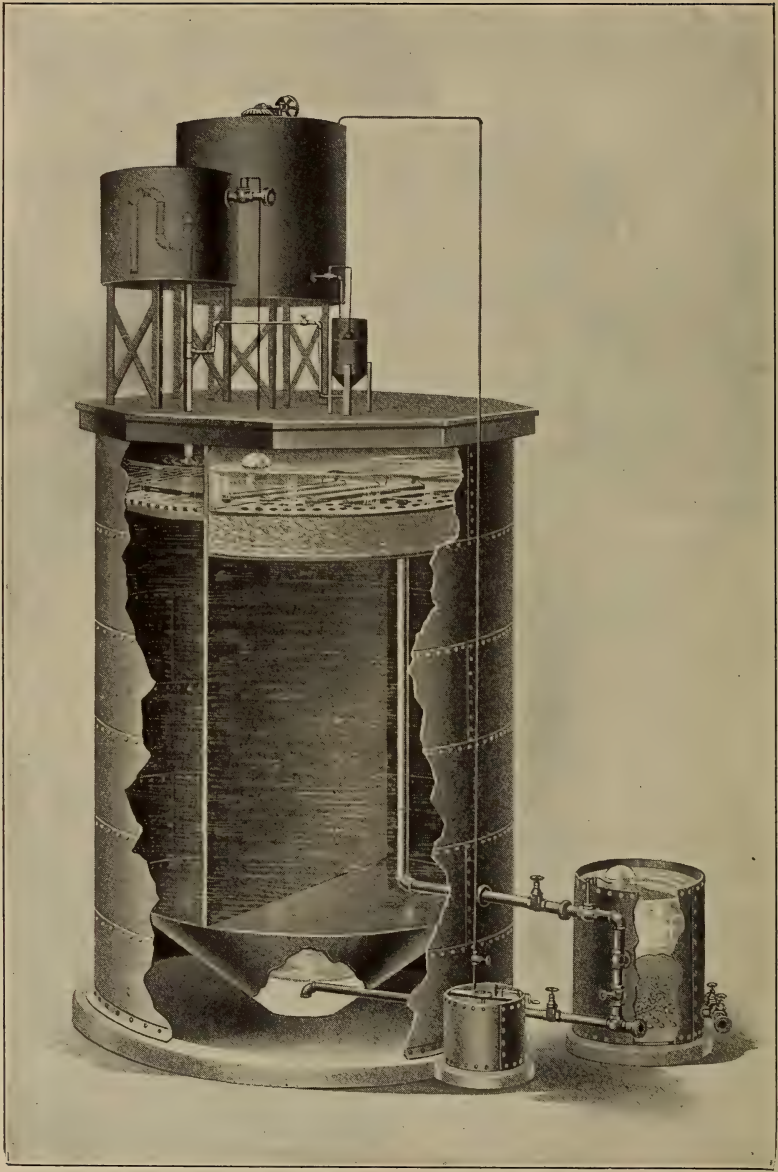
IT is now generally realized that the proper way to keep steam boilers clean is to feed them with water free from impurities. The idea that water containing in solution any salts or other matter in solution or suspension should be fed directly into a boiler, there to be deposited in the form of scale and sediment and more or less imperfectly removed thereafter, is known to be fallacious and costly.

The cost of the generation of steam and the maintenance of a boiler plant is largely dependent upon the character of the water which is fed into the boilers. Naturally, pure water for boiler feed is the exception, and not the rule, as is demonstrated by the extent to which boilers supplied with raw water generally become scaled and corroded. This prevalence of so-called "hard" waters has led to the development of chemical processes for the removal of the substances which cause the scale and corrosion. This process, known as water-softening, is based upon the correct knowledge of the quantity and chemical character of the impurities present, and, by the removal of the objectionable substances, it provides a relief from the effects of scale and corrosion. It is a method based upon accurate chemical knowledge, and does not depend upon chance or imagination to demonstrate its effectiveness. By the addition of the proper reagents in the correct proportions, the matter in solution is precipitated, and the resulting precipitates, together with the suspended matter, are then removed by sedimentation and filtration.

Although the chemical principles involved in this operation are definite and well known, much depends upon the mechanical design and construction of the apparatus in which it is effected. The addition of the reagents should be made in the correct and predetermined amount, and the mixture with the raw water be thoroughly and effectively completed; the opportunity for sedimentation should be ample and the purified and filtered water drawn off for use as demanded by the boilers. Furthermore, the apparatus should be free from complications and capable of operation by such attendance as is generally available in steam power plants.

Among the various types of water-softening and purifying systems manufactured by Wm. B. Scaife & Sons Company, of Pittsburg, Pa., is an automatic continuous system, known as the syphon system, so called because its operation depends upon the action of the syphon.

The water entering the system flows into the syphon tank, shown in the illustration, until a height is reached sufficient to start a flow through the main syphon, which then continues to flow until the tank is emptied. When the main syphon begins to flow it starts the auxiliary syphons, which introduce the reagents into it during its period of flow. As soon as the tank from which the main syphon operates is emptied all syphons stop flowing until the tank refills to the point where it again starts the syphons flowing. The harmonious action of these syphons depends upon the head of water in the tank and not upon the incoming rate of flow.



SYPHON WATER PURIFIER

It is, of course, evident that the main syphon will always start and stop under the same conditions. This being the case, the auxiliary or chemical-introducing syphon will always operate under the same conditions. It will, therefore, be readily seen that the chemicals are not only introduced in exact proportion, but in exact amount to a certain definite amount of water determined by the strength of solution and the setting of the valve in the auxiliary or chemical syphon.

The chemical syphon, as will be seen in the cut, is fed from a small constant level solution tank connected with the main solution or solution storage tank. The flow to the constant level solution tank is controlled by float, to keep the head under which the chemical syphon is operated always the same. The conditions for operation of the chemical syphon are, therefore, controlled only by the flow in the main syphon, which, in turn, is dependent only on the water entering the syphon tank.

After mixture of water and reagents in the discharge pipe of main syphon, water and reagents are dashed against a baffle located below the waterline in the reaction compartment of treating and settling tank.

This completely mixes water and reagents, giving it the much desired rolling motion.

A further advantage will be noticed upon referring to the illustration, in that the discharge from the syphon is deflected upward and outward, so that the delivery through the slatted partition into the reaction chamber is not directly from the syphon discharge, but by a difference of water level in the two compartments of the treating and settling tank.

As this movement of the water is intermittent and the discharge from the syphon very rapid, the level of the water above the slatted partition becomes higher than it is at the same instant in the compartment over the filter, and it therefore exerts uniform pressure over the entire area of the reaction chamber and produces on the entire volume of the settling compartment and through the whole area of the wood fibre filter a movement corresponding to the difference in head. This being the case, there is little or no chance for dead spaces, all of the water in the entire tank being moved simultaneously with the flow of water at each discharge of the syphon.

However, to absolutely prevent any possibility of short circuits in the settling compartment, a collecting header is placed above the excelsior filter, the openings in which are placed so as to draw the water uniformly from all parts of the settling tank. From this header the water flows to the heater or boiler, or wherever it is to be used.

In the event that clear water is desired, a mechanical gravity filter, as shown in the cut, is furnished, to remove any suspended matter left by the excelsior filter. Where it is desired to discharge the water at some height—for instance, into an open heater—a mechanical pressure filter can be substituted for the gravity filter.

The reagents are dissolved in the reagent mixing tank shown on the ground, and, by means of a steam jet pump or any other means, delivered to the solution storage tank, located on top of the tank, twice every twenty-four hours, or as often as may be desired, depending upon the conditions under which the system is operating.

It is sometimes desirable to make the system completely ground-operated, in which case a steam engine, electric motor or water motor can be used to lift the chemicals from the solution storage tank located on the ground to the constant level syphon feed tank. Any excess solution is returned to the solution storage tank by overflow.

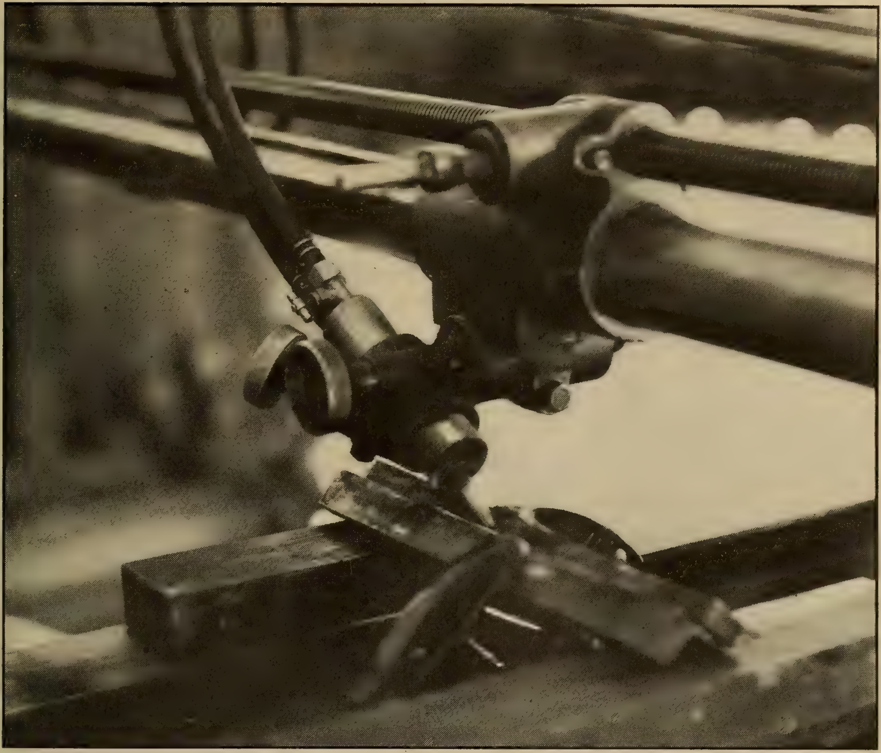
The accuracy and simplicity of this system are almost ideal. The design can be modified to adapt it to a great variety of operating conditions, and it meets all requirements for the complete and perfect softening and clarification of any water for boiler feed or industrial uses.

# ACETYLENE WELDING AND CUTTING MACHINE

HAND welding and hand cutting are now familiar operations to which the acetylene blow-pipe is highly adapted. Where straight-line operations have to be carried out, especially in connection with repetition work, a machine is often applicable and advisable. Where sheets are very thin, machine welding is very desirable because of the certainty with which it can be regulated. The machine can be advantageously used in sheet metal work, where the thicknesses range up to, say, 3/16 or 7/32 inch. Straight cutting of both thin and thick work can be advantageously done with the machine because of the precision of the movement.

An acetylene welding and cutting machine has recently been built by the Davis-Bournonville Company of 90 West street, New York City, at their laboratory at Marion Station, Jersey City. The patent rights involved are held by this concern. There is a cylindrical upright, perhaps 6 or 7 feet in height. This carries a long hollow arm projecting for 6 or 7 feet on one side. By means of a rack and pinion, this arm may be adjusted to any height desired. The arm carries a long screw, rotatably and horizontally mounted in suitable bearings. At the base of the upright, loose and tight pulleys are mounted on a short horizontal shaft and are driven from an ordinary countershaft above. At one end of this short shaft a friction pinion is arranged, which contacts with a suitable rod arranged in the hollow arm shaft. This latter shaft and a rotable rod arranged in the hollow arm are put into driving connection by bevel gears. At the outer end of the arm an arrangement of gears enables the inclosed rod to drive the screw. The turning of this screw operates a carriage back and forth horizontally along the arm. Upon the carriage the torch and its controlling fixtures are mounted. The work is placed or secured on a suitably fixed table. Flexible tubes bring the oxygen and acetylene to the torch. The tip is practically the ordinary form. It is arranged at an angle, say 40 or 45 degrees to the horizontal, this angle being to the rear of the welding movement. The torch then moves over the work much after the way a cowcatcher passes along over a railway track.

The method of welding is often quite simple. Thus, if the weld is to be a flat one and of inconsiderable length, the two pieces are simply clamped in the exact relative positions they are to occupy finally. Room must, of course, be left for the tip to pass. The operation of welding is then not unlike that which occurs with an ordinary shaper. The carriage, with the torch, moves evenly along at the proper rate of speed. The countershaft, running at say 140 revolutions per minute, operates the short horizontal shaft at about 70 revolutions. It is possible to adjust the friction pinion to vary the angular speed of the vertical shaft from about 70 to about 35 revolutions. Still further reductions of speed may be made by the gears at the end of the arm. Indeed, quite a range of speeds may be obtained by suitable combinations of the gears. The screw has about six threads to the inch, and gives the carriage a speed



ACETYLENE WELDING TORCH

which may be varied from 3 to 24 inches per minute. The carriage has a back-and-forth range of 5 feet 5 inches, which means that a weld of approximately that length may be made. If an angular weld is to be formed, the only difference to be made is in the arrangement of the work. The angle opens downwards, and the vertical plane through the line of the weld bisects the dihedral angle. To illustrate by a practical example, we will suppose that it is desired to weld two strips edge to edge at an angle of 90 degrees. We place the strips on the sides of an angle bar, clamping them securely in position with clamping strips inserted between the outer faces of the work and the jaws of the clamps.

There is a possible economy which is possible with hand welding, and which will probably come into pretty general use where the machine is used. The object of using an oxy-acetylene torch is for the purpose of getting a very high temperature. Because of the enormous temperature of about 6,000 degrees F., which is claimed for the working points of the little inner flame, this torch is very successful in bringing steel and other metals locally to or near the melting point. Ordinary flames are incompetent to do this. But the ordinary—and cheap—flame is competent to supply a large amount of the requisite heat. Where the form and character of the work do not prohibit, there seems no reason why preheating by cheap methods should not be employed. In other words, it is not necessary to do all the heating with gases like acetylene and oxygen. The saving is, however, not connected with the consumption of the gases alone; time may also be saved, and this means economy of the labor and the machine. For example, certain work requiring a long seam and involving sheets 0.10 to 0.12 inch thick can be welded on a European machine at the rate of about 12 inches per minute. Practical experiments, where the work was pre-heated before passing under the torch, showed, so it is said, that the work—and I understand it to be the same class of work—can be welded at a speed of 26 to 28 inches per minute. The economy in time is striking. The methods of preheating may be various. Thus, if it is a question of small repetition work, the preheating may in some cases be done subsequent to clamping, but prior to putting the work on the table. Other cases will require pre-heating with the work in welding position. In general, the pre-heating arrangements will not be difficult to provide. Pre-heating is to be recommended strongly for the two reasons—economy of oxygen consumption and reduction of effects of expansion and contraction.

The machine already described as a welding device can readily be used as a cutting apparatus. The high precision of the motion of the carriage recommends it for this purpose. In cutting, however, some variations are made. In the first place, the jet arrangements are different. But this is perhaps more a matter of simultaneous development, as the new arrangements of jets will no doubt be effective as a hand tool. On the machine three jets are arranged in a rigidly vertical position, the gases being driven directly downwards. These are arranged in line with the direction of movement. Ahead is a heating jet of oxygen and acetylene; at the rear is another but smaller heating jet. Between the two the cutting jet of oxygen is arranged. Three flexible tubes bring the gases. An oxygen and an acetylene tube together supply the gases for the two heating jets. Thus these jets are both supplied from the same sources. An independent oxygen supply is provided for the cutting jet, for the reason that ordinarily the pressure back of this jet is higher—and sometimes much higher—than is the case with the heating oxygen. By the foregoing arrangement of jets, a strong heat is provided just ahead of the cutting oxygen and a moderate one just behind. The office of the jet ahead is pretty well known; it raises the steel to the temperature of combustion. The pure oxygen then enters the game and the metal is "cut." It has been found, however, that by providing an auxiliary heater behind, the work of cutting is facilitated. Its operation is probably as follows: The forward jet provides heat for the metal which is probably somewhat lost by the time the pure oxygen jet comes along. This jet may be only three-eighths of an inch behind. Still it would seem that conduction would carry off considerable heat while the cutting jet is getting to the spot, especially where the movement is a slow one, as with very thick steel. The rear jet provides additional heat and thus reduces dissipation by conduction. Its scene of operation is in the region where much of the wasteful conduction would take place. In the case of thin plates the rear jet is scarcely necessary and may be shut off. The whole arrangement is readily replaced, and thus is permitted an economical adjustment to the size of the work.

# THE RAILWAYS AND THE PUBLIC*

By Howard Elliott

EVERY man working for a railway to-day has a great responsibility—greater than ever before—and the passenger man, because of his position, his training and experience, is qualified to assume his share of that responsibility.

For many years, and particularly in the last few, there has been agitation about the so-called railway question or problem. Through lack of complete information about the railways, there has arisen some antagonism toward them, and it is important to explain the real situation, because the American people, when they know the truth, are not likely to be unjust to any one class of people or to any one business.

Upon one hand there is a critical public. Upon the other, the railways are struggling with forces which are causing rates to remain stationary, or to decline; causing wages to rise or to remain stationary; bringing demands from a prosperous and luxurious people for increasingly expensive facilities and service, and causing taxes to rise at an alarming rate.

These four forces are all at work reducing the margin between income and outgo, and making it more and more difficult for the owners of railway properties to keep their lines in suitable condition to carry the business of the country, and to obtain a return commensurate with the risk of the business and sufficient to attract further investment.

Railway officers have been less active than they should have been in keeping in touch with the public. The railway stockholders have not realized how strong the forces affecting their properties are. This condition has changed, and the modern railway owner, officers and employees should and do realize that it is necessary to maintain cordial and friendly relations with the public, and by their personal efforts and example to give full information about the business, and to build up a constantly better feeling towards the transportation machine of the United States.

It is no doubt true that little things—the abruptness of an agent or a trainman, a lack of proper courtesy, inattention to complaints of the public, dilatoriness—often caused quite as much criticism from the public as things of greater importance. This irritation and criticism can be reduced by adjusting the relations between the railways and the public at the point of contact. The passenger men and their representatives in 1909 came in contact with each one of nearly nine hundred million users of railways. In each of the nine hundred million instances some man had a chance to make or mar the reputation of his line, and to affect just a little the attitude of the people toward the transportation business. Nine hundred million instances of courtesy and attention, or nine hundred million passengers completing a journey with a feeling that the railway was interested in their comfort and pleasure, would constitute a great leverage, moving public sentiment into better channels.

The passenger man cannot only build up cordial relations in the best way—and that is through pleasant contact of the individual with the individual—but has an opportunity to do an increasing amount of work in placing before the people the real facts about the railway business of this country, and can have a growing influence in showing a majority of the American people, who are only unfair because they do not fully understand this question, that the railways cannot indefinitely provide increasingly good service at rising costs, which the public demands and should have, and survive, unless there is more reason in directing and controlling the four forces I have mentioned.

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* Extracts from an address by the president of the Northern Pacific Railway, before the American Association of General Passenger and Ticket Agents, St. Paul, Minn., September 20, 1911.

There is plenty of information at hand about the railway business. No form of business in the United States is conducted so openly and in none are the facts and figures so available. This information does not reach the everyday citizen who is interested, but lacks ready sources of information, to the degree that it should. The passenger man can do a great work by seeing that it does.

The press of the United States reaches the people. In 1909 there were 22,603 publications issuing a total of 10,600,000,000 copies per year. The press can help the relations between the public and the railways by giving correct information, and, if approached properly, will usually manifest a fair attitude. The passenger man has a responsibility in this respect, and with his more intimate knowledge of the business he can help the newspapers to avoid misstatements and false conclusions.

The drift of population in the United States is away from the country and into the cities. In 1840, slightly more than one-fifth of our people were engaged in commerce, manufacturing, mining and transportation, and in 1900 more than two-fifths were so engaged. Agriculture claimed 77½ per cent. of our people in 1840, and in 1900 but 35½ per cent. Four-tenths of our people are living in cities of 8,000 or more.

Passenger and immigration men and those in charge of exploitation can do a great national work in helping along the movement toward the land, and in aiding the people to get out of the crowded cities, breeding discontent, socialism and great suffering. The Bureau of Immigration reports that about 1,000,000 people a year come to the United States from Europe, and for the year ending with June, 1910, only 140,120 went west of the Mississippi River. It is better for the newcomer that he avoid the crowded industrial centers and live where he can produce food and wealth out of the ground, making a profit under good living conditions and increasing national production rather than to increase the horde of consumers in the crowded manufacturing districts.

The passenger man can make money for his railway by helping the movement of people back to the land, and at the same time perform a patriotic service to his country.

Steadily increasing public expenditures in this country are increasing all forms of taxation, which in turn bear heavily upon the railway investment and affect the daily lives of every man who is employed by a railway company. From 1900 to 1908, the ordinary expenses of the United States government grew 121.4 per cent., and in thirty selected States the public expenditures increased 201.6 per cent.

The passenger man, in addition to the regular duties of his office, can lend his influence toward checking the national tendency toward extravagance, and can set an excellent example by care in the administration of the duties entrusted to him, by checking waste in all forms, and he can protect the owners of the property he represents by seeing to it that while the public is furnished clean, safe and regular transportation, it is not being given a service which is costing more than the users pay for it.

The National Monetary Commission estimated the annual expenditures of those who visit Europe at $200,000,000. The editor of the London *Statist* places the figures at $170,000,000. Some New York bankers, in discussing the matter with well-posted French financial authorities, thought the total was nearly $400,000,000. There is sufficient evidence that the amount is between $200,000,000 and $400,000,000. This immense sum is annually taken out of this country and spent abroad by people who have gone away from home in search of health, rest and pleasure which they might easily find nearer by.

If our own land were better known, much of this economic loss could be stopped, and the passenger man has an attractive field of work in so placing before the average American citizen the beauties and advantages of his own country that he will spend an increasing share of his travel time and these enormous sums in this country, thus keeping American money at home, and aiding in the development of the regions which offer so much, not only to the tourist, but to the homeseeker. We have mountains, scenic wonders and an out-doors comparable with anything Europe can offer. Each dollar diverted from Europe to our home regions assists in giving them continually better facilities for the accommodation of travel. Much of what we have to offer is unique and can be seen by the traveler in no other country.

So, I repeat, we in the railway business have a greater responsibility than ever before; not only the responsibility of doing our best, whatever may be our position in the service, but the responsibility of telling the people the real facts about the railway business—the responsibility of using our opportunities to aid the nation by helping the movement to have a greater proportion of our population live in the country than in the cities—the responsibility of directing the attention of the tourist to the beauties of America, so that the money now going to foreign lands will remain here and help to increase the balance of trade in our favor—and last, but not least, the responsibility, which to-day is a great one to every American and to every railway employee, of encouraging the practice of those habits of industry, thoroughness and thrift which are not so common in the last twenty-five years as they were when our country began its work of becoming a great nation.

# A STUDY IN MACHINERY EFFICIENCY

THE extensive operations on the Panama Canal offer rare opportunities for observing the efficiency of many kinds of machines and to ascertain the losses incident to the temporary shutdowns for repairs. When the machines are but links in a productive chain of labour and mechanisms these losses reach their maximum. That these losses are much larger and of greater importance than is generally believed is proved by figures arrived at by the engineers in charge of building the Gatun Locks, where the chief operations are carried on by means of eight Lidgerwood high-speed cableways. In order to arrive at the cost for delays, the engineers computed the loss that occurs to the government for each minute the cableways were out of service, during working hours, for repairs, or in outside use. Their figures show that this loss, which is mostly incident to interrupting the chain of operations, amounts to $1.50 per minute for each cableway, or $3 per minute for each pair of duplex cableways.

When it is considered that if these delays amounted to only ten minutes a day on each cableway that this would total in a year (300 days) $4,500 per cableway, or $36,000 for the eight, it becomes evident that the percentage of actual efficiency for this or other machinery becomes of high importance.

In this respect the cableways in use at Panama show a very high degree both of actual efficiency and of relative efficiency, as compared with the best product of the same company as built for use elsewhere.

A recent report says that the eight cableways used for placing the concrete in the locks have been out of service for repairs of all sorts but 1 per cent. of the working time for nearly a year's continuous use. On the Chicago Drainage Canal, the largest single operation where cableways were employed, the twenty Lidgerwood cableways showed for the first few months an average loss of time for repairs during working hours of about 45 minutes per day each. Later on this was somewhat reduced. On the basis of the Panama report this would make a difference in efficiency of 6½ per cent. in favour of the Panama cableways, or, putting it into dollars and cents, the Panama cableways have an actual earning capacity of $20,250 a year each more than those used for the Drainage Canal. This improvement in performance is the result of careful and exhaustive inquiry as to the source of time losses and of experiment as to how to cure them.

A vital feature of a cableway is an efficient fall rope carrier system, and it is in the fall rope carrier system that the greater portion of all delays originates. In the Chicago Drainage Canal type of cableways the button-controlled style of fall rope carriers was used. These were far and away superior, both in earning power and maintenance, to the old chain-connected carriers, and proved capable of allowing load carriage speeds up to about 800 feet per minute without causing excessive repair losses. Above that speed the repair losses became burdensome. The difficulty seemed to be—

(a) In the form of button;

(b) The manner in which it was

held in place on the button rope, and

(c) In the shape of the carrier heads which collided with the buttons.

The button was long and conical and entered wedge-like into a slot in the carrier head. The carrier heads were slotted in forged steel, but, no matter how heavy they were made, the impact effect seemed to increase in proportion to the weight and the wedge-like buttons split the heads. The impact on the button was also destructive to the button ropes. These had frequently to be renewed. The button was made in halves, divided lengthwise, and screwed together. It enclosed a pair of spreaders put into the rope and a babbitt metal bulge cast around the rope within the button. The surface of the rope which received the shock was so small that the wires were soon cut and the ropes destroyed.

The specifications for the Panama Canal cableways called for capacities which involved load carriage speeds of 1,800 feet a minute. The guarantee has been more than met, and some of the cableways have been operated up to 3,000 feet per minute.

Three important improvements appear in the Panama cableways, which not only have made them capable of meeting the makers' guarantees, but even under those trying conditions keep their repair losses down to a figure never before approached. This type of cableway is, therefore, as much superior to the type using the older buttons and carriers with slotted heads as those were superior to those using chain-connected carriers. The button was first improved. Instead of being made in two pieces, it is now practically a single steel forging bored out with a long, tapering recess. The rope is made to fit this recess for its entire length by inserting in the rope a properly tapered steel pin in place of the hemp centre. This gives a bearing of such large area to receive the shocks from the carriers as to thoroughly prevent any tendency to cut the rope. A follower fits into the open end of the button and serves to finish its contour. This is held in place by a small spreader inserted in the rope back of it. These buttons, and the rope carrying them, have withstood without damage months of use at the Lidgerwood cableway testing station, at Newark, where for long periods the carriage speeds have been up to 3,000 feet per minute.

The next and most revolutionary improvement was in the form of the fall rope carrier head. This was changed from a slotted head to the form of a steel eye. As the eye comes into contact with the end of the button around nearly the whole circumferential face instead of at two points only, all splitting tendency was at once eliminated. Weight was also saved, as the eye weighs but a tenth part of what the slotted head did. It was found necessary also to hang the eye in the carrier so that the eye was free to swing when it was picked off the carriage. This was found to absorb a considerable part of the shock. A second joint was introduced in the carrier head below the eye. With the two joints the shock is so thoroughly absorbed that its destructive effects at speeds up to 2,000 feet have disappeared. This is the form of the present Lidgerwood fall rope carrier.

Incidental to and following these changes improvements of importance were made in the carriage.

The horn, which carries out the fall rope carriers to the buttons and picks them up again upon the return trip of the carriage, is mounted separately from the carriage with its own wheel running on the main cable. The horn mounting is connected to the carriage with a pivoted connection, so that the horn always keeps a position in line with the cable, no matter what the curve of the latter may be. This insures the picking up of the carriers, and this with the least shock, as the horn enters them always at the same point.

The carriage proper has three

bearing wheels on the main cable. Two of these are mounted in a pivoted bearing, so that they can adjust themselves always to the varying curves of the cable. This distributes the weight and the wear equally between these two wheels and contributes considerably to the life of the main cable. The increase in economical load carriage speeds from 800 to 900 feet per minute to 1,600 to 1,800 feet has nearly doubled the capacity of the cableway, and this alone is an assurance that the cableway will for years continue to be one of the most effective tools of the civil engineer and contractor in important undertakings.

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# GAS POWER FROM LOW GRADE FUELS

By R. H. Fernald

EXTRACTS FROM A REPORT TO THE UNITED STATES BUREAU OF MINES

THE analyzing and testing of mineral fuels as carried on by the United States Geological Survey included trials of coal, lignite and peat in a gas producer. These tests were made in connection with steaming and other tests, the object of the investigation being to find out in what ways the mineral fuels of the United States could be utilized most efficiently and by what means deposits of low-grade fuels that were lying undeveloped or were being wasted could be made of immediate or prospective importance as assets of the nation's mineral wealth.

The tests of fuels for producer-gas manufacture began in 1904 and were continued by the United States Geological Survey up to July 1, 1910, on which date all of the fuel-testing work being carried on by the Survey was transferred by act of Congress to the Bureau of Mines. Results of some of the producer-gas tests made before that date have been given in various publications of the Geological Survey; results of other tests will be given in bulletins to be issued by the Bureau of Mines.

In the course of its investigations the Geological Survey collected information relating to the development of producer-gas power plants in the United States, giving particular attention to the fuels used, the efficiencies obtained and the operating troubles or other drawbacks reported by owners. To get further particulars regarding the possibility of utilizing fuels undeveloped or wasted, the writer was authorized to visit those European countries where gas producers and gas engines are more widely used than in the United states, and to inspect those plants which had been most successful in utilizing poor fuels.

Because the limited time would not permit a careful inspection, much less a detailed study of all the plants visited, the writer has not aimed to present a comprehensive review of producer-gas development in Europe, or even to give such conclusions as might be drawn from what he saw, but has simply described some interesting features of European practice that attract the attention of even a casual observer.

Suction producers fed with anthracite or coke are in general use at small power plants in Great Britain and on the Continent. They seem to give satisfaction, although their operating cost is apparently somewhat greater than the figures stated by the manufacturers. The number of producer-gas power plants in England has become so large that it is said to have caused an advance in the price of anthracite. In one city I was told that the price of a grade of anthracite had been $4.85 a ton before the introduction of gas-producer plants, but had risen to $7.25 since.

Coke is used abroad much more generally than in this country. Many users say that it gives best results when it is crushed to walnut size. Some English power-plant owners, to reduce fuel bills, used a mixture of the two fuels (coke and anthracite) in their producers, as the price of coke in 1908 was about $3.75 a ton.

A manufacturer of a suction plant in general use advertises "20 horse-power-hours for 1*d*." on coke. The writer investigated one of these plants and was informed by the owner that, although coke cost him only about one-half as much as anthracite, he was obliged to use twice as much, so that the expense for fuel was practically the same whichever fuel he used. Under average conditions the fuel cost of power was 1 penny for about 9 horse-power-hours. Under the best conditions the plant might develop 12 or 14 horse-power-hours on 1 penny's worth of fuel, but would not develop 20 horse-power-hours on that quantity.

In Belgium the anthracite generally used in suction plants seems to give entire satisfaction. At some plants it was reported that the anthracite contained 6 to 8 per cent. ash, practically no sulphur, and little tar. The coal shows little tendency to cake, and its average heat value is 13,500 B. t. u. per pound. It costs $3 to $4 per ton at the mine.

In Germany gas producers of both the suction and pressure types burn anthracite, and all kinds and sizes of gas engines are built to run on producer gas. In 1908 one company was turning out 400 engines a month, most of which were to use this gas.

Small producer-gas plants of the suction type that used good anthracite were reported to require from 0.7 to 1 pound of water for the vaporizer and from 10 to 15 pounds of scrubber water for each pound of coal fired.

One practice of some of the engine manufacturers in Europe that deserves commendation is not to overrate their engines. For example, many engines rated at 50 will show 60 brake-horse-power continuously under test, and those rated at 35 to 40 will show 50 horse-power. This gives an overload capacity of apparently 20 to 30 per cent.

Some of the companies that formerly made all their producer-gas engines of the hit-and-miss type now make all their large ones of the constant-mixture, throttled type.

Some manufacturers showed suction-type producer outfits especially designed for burning anthracite screenings. These outfits seemed to be of serviceable design and construction, but the author saw none in operation outside of the works of the various manufacturers.

Owing to the fact that the wholesale price of sulphate of ammonia in the principal markets is from $55 to $60 a ton, the recovery of ammonia as a by-product in the manufacture of producer gas is a very tempting project. The possible financial return seems especially inviting when one realizes that a ton of the ordinary grades of bituminous coal yields, when gasified, about 90 pounds of sulphate of ammonia. In addition, it is often possible to find a market for the pitch and tar produced.

Anthracite is not suited for any profitable ammonia recovery, owing to its small percentage of nitrogen and also to its high first cost; but the cheaper grades of bituminous coal, with an average content of about 1.3 per cent. nitrogen, are especially adapted to the successful operation of by-product plants, provided the plants are of sufficent capacity to reduce the operating expenses and fixed charges per unit of output to a reasonable figure. Attempts to recover by-products at plants of small horse-power have not proved successful financially. The impression the writer gathered abroad is that no attempt should be made to recover by-products in plants of less capacity than 4,000 horse-power, although by-product recovery plants of much smaller size are in operation.

In the pressure-producer plants the tar is extracted mechanically and forms a by-product which is usually of little commercial value; consequently, it becomes a nuisance about the premises and must be drained or carted away. At some places attempts are made to burn it, either in furnaces or in the producers themselves; but, in general, such attempts have not met with favour, save possibly for certain types of down-draft producers.

One method of utilizing the refuse tar in vogue at certain foreign plants is to mix it with the ash and then to spread the mixture in the yards for walks, roads, etc. There is a limit to this use, however, as the entire yard eventually becomes covered to the maximum depth allowable.

At one European plant visited there is special equipment for handling the tar and preparing it for commercial use. The tarry water runs into a large vat or cistern and most of the tar is separated from the water as the mixture passes over a series of screens. The tar with a reduced percentage of water is then drawn off into a large tank fitted in the bottom with pipes for exhaust steam. By means of the steam the tar is kept warm enough to facilitate its being pumped through a pipe line to tank cars on the near-by railroad. The tar as shipped often contains as much as 20 per cent. water.

The average weight of water-free tar recovered in this plant is 90 pounds from each ton of fuel fed to the producer. The water-free tar sells for about $4.25 a ton, a price which yields a return of approximately 19 cents on each ton of coal fired, not taking into account fixed charges and the labour expense of separating the tar. These items, however, amount to little. The tar is used as a binder for fuel briquets and as a basis for various medicines.

In Europe the demand for small power plants to use bituminous coal is quite as evident as in this country. The leading manufacturers of gas producers are all working on suction plants for bituminous coal, and each apparently feels that his model is the only successful one. But each manufacturer places special restrictions on the kinds of fuel that may be used. One manufacturer states that the bituminous coal to be used in the suction plant of his design must be of good quality, low in ash (say 8 to 10 per cent. as a maximum), and non-caking, and must not contain more than 7 per cent. tar. Another manufacturer makes the statement that for other than anthracite coals the users of his products confine their attention to short-flaming, low-ash fuels that yield little tar and do not cake.

Although the writer saw several of these suction plants especially designed for bituminous coal, he found only one in actual operation. This was a double-zone plant of 250 horse-power supplying gas to a 150-horse-power horizontal single-acting twin engine. The coal used was reported to contain 25 per cent. ash and 2 per cent. sulphur. It was claimed that, so long as the coal was non-caking, such high ash content gave no trouble. In this installation it was imperative that only coals possessing certain qualities should be used. To comply with these limitations it was often necessary to procure three varieties of coal and to mix them in the proper proportion. All fine coal was sifted and the dust was thrown out to prevent matting. With such restrictions imposed, it is difficult to see how similar plants can meet commercial demands. All the makes of suction plants for bituminous coal that were inspected were of the double-zone design.

The general situation in Europe regarding the use of low-grade bituminous coal is not much unlike the situation here. For the most part, the better-grade coals are being used and the poorer grades are being left in the mines. It is true, however, that this condition is recognized abroad as a serious one, and there is deep interest in the possible utilization of low-grade fuels in the gas producer.

In discussing the matter with the writer, one of the best informed producer-gas experts of England expressed the opinion that the proper way of beginning investigations relating to the general development of the field for producer gas was to take up the utilization of low-grade fuels. He said that such utilization was as important in England as in America, and regretted that more active work along this line had not been undertaken in the former country. He also said that plants for low-grade fuels will eventually be perfected by working on a basis different from the present, for he believed many radical departures from the practice of to-day must be made to get the proper solution of the problem.

By careful inquiry the writer was able to learn of only two plants that are endeavoring to use low-grade coal extensively. One of these plants at the time of his visit was still regarded as in the experimental stage, though it had been erected a year before and had given excellent satisfaction for several months. This plant was of the Mond by-product type, with details modified to suit the peculiar requirements of the low-grade, high-ash material used as fuel. This material consisted of a mixture of three varieties of refuse — namely, small-size waste material from the principal dump of the mine, large pieces of clay and rock that, when broken, showed traces of coal, and fine sludge from the coal washery. The first of these materials was reported to contain between 60 and 70 per cent. ash and the others contained smaller percentages, so that the total ash content of the mixture as charged into the producers was between 50 and 55 per cent.

A particularly interesting point noted was that large earthy slabs containing almost no coal yielded a large percentage of nitrogen, in many instances far above that obtained from the coal.

Among the most interesting producer-gas plants in Europe are those utilizing peat as fuel. The peat resources of Europe are extensive and are being rapidly developed. In many countries piles of peat dug for household use may be seen from the railroad trains. In some countries this fuel has thus far been used entirely for domestic purposes, but in others peat forms the main fuel supply for power and manufacturing plants.

The bogs of Ireland have for generations supplied peat for domestic fires; but, although the bogs are extensive, the peat has not been used much for generating power. In 1908, however, projects were being considered that involve the erection of extensive power plants in the bogs of Central Ireland and the transmission of electric current to Dublin.

Peat has been most largely used in Holland, Austria, Germany, Denmark, Norway, Sweden, Finland and Russia. In Holland peat has been used for hundreds of years, and the bogs have yielded large returns. By the methods pursued, not only is the peat utilized, but the bog is left in excellent condition for agriculture.

In Austria and Germany much progress has been made in utilizing peat, especially in the manufacture of peat coke and the making of sulphate of ammonia from peat by means of by-product recovery plants. Doctors Frank and Caro have done much to advance ammonia recovery by their process of gasifying peat in a mixture of air and superheated steam. They find it possible to gasify peat containing 50 to 55 per cent. water, thus saving much of the time usually required for drying. Although much of the peat thus far used in these by-product plants contains only about 1 per cent. nitrogen, the returns have been surprisingly good, 40 or more pounds of sulphate of ammonia being obtained from each ton of peat fired.

Doctors Frank and Caro state that from an English peat they obtained 118 pounds of sulphate of ammonia per ton of water-free peat. The gas from each ton of fuel generated all the steam required by the plant and produced power equivalent to 480 horse-power-hours.

Doctor Frank believes that the process will pay with peat containing only 1 per cent. nitrogen. The peats of the United States contain a much larger amount of nitrogen than those of Europe, and Doctor Frank is confident that this process, if applied to them, will prove very profitable.

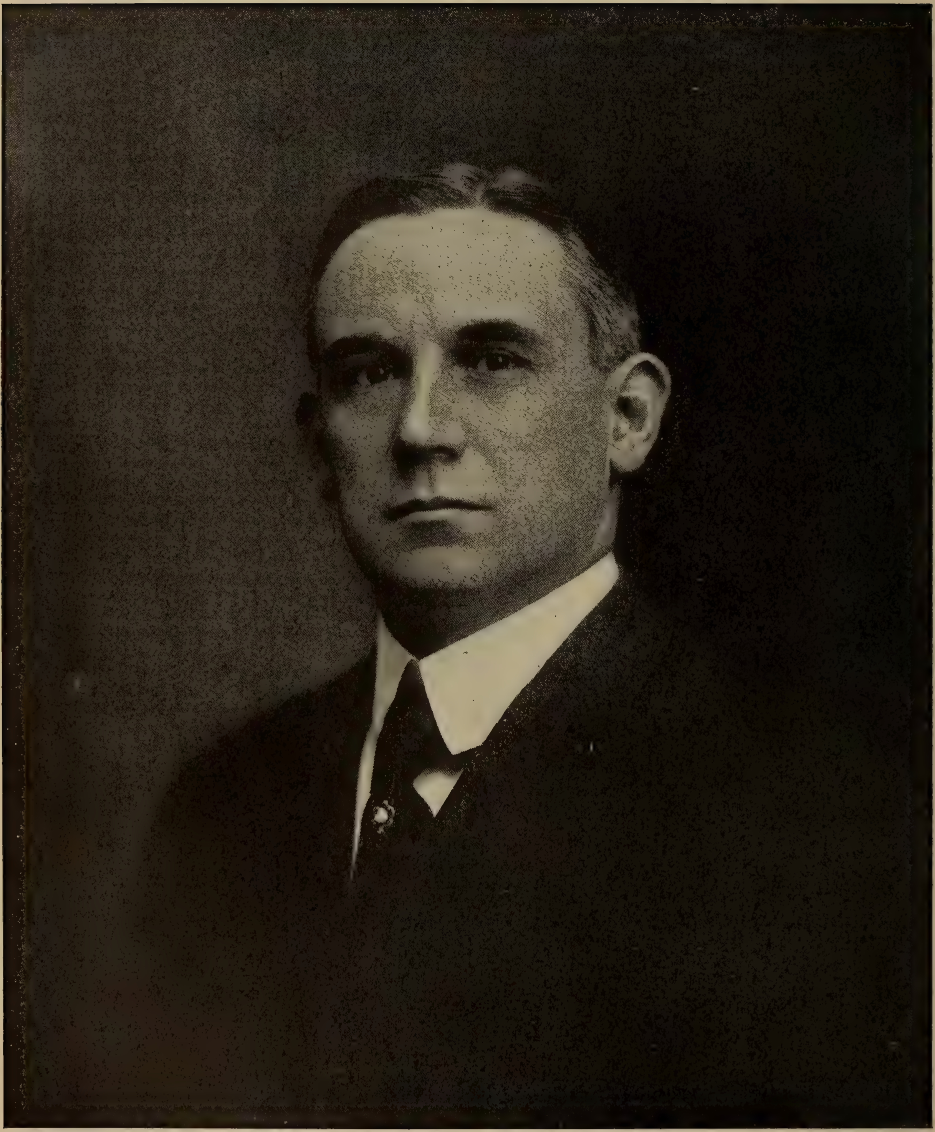
Messrs. Crossley Brothers report that at their works they recovered 134 pounds of sulphate of ammonia from a ton of chemically dry peat containing 2.24 per cent. nitrogen. They also report that 1,000 horse-power-hours could be obtained from the gas from each ton of dry peat.

Since the supply of bituminous coal or lignite is large in some countries, the necessity for utilizing the peat resources is not so great in them as in Norway, Sweden, Denmark and Finland. A recent report shows that Russia leads in the production of peat for generating power, the quantity dug reaching 4,000,000 or 5,000,000 tons a year.

The principal manufacturers of gas producers and producer-gas engines are now putting out double-zone producers designed especially to use peat. These small peat-producer plants for generating power are widely used in Europe, although the first plant of this type was installed no longer ago than 1904.

Mr. Arthur Lyman Williston, the head of the Wentworth Institute, Boston, is well known as one of the most successful leaders in technical education in the United States, and his recent transfer to the new institution in Boston calls attention to his equipment for such an undertaking. Mr. Williston was born in Cambridge, Mass., in 1868, and received his technical education at the Massachusetts Institute of Technology, after which he was engaged in practical engineering in the Maintenance of Way Department of the Union Pacific Railroad, and in the Chief Engineer's Department of the Big Four Railroad; also as mechanical engineer for Lockwood, Greene & Co., mill architects of Boston, Mass. After experience as Instructor in Steam Engineering in the Massachusetts Institute of Technology and as Director of the Department of Industrial Arts of the Ohio State University, Mr. Williston became Director of the School of Science and Technology of the Pratt Institute, of Brooklyn, N. Y., which position he held from 1898 to 1910, when he became the head of the new institution which has been endowed with more than three and a half million dollars by the late Arioch Wentworth, of Boston, for "furnishing education in the mechanical arts."

Professor Williston is a member of the American Association for the Advancement of Science, of the American Society of Mechanical Engineers, of the Society for the Promotion of Engineering Education (secretary, 1907-1909; vice-president, 1909), member of the National Society for the Promotion of Industrial Education (secretary-treasurer, New York State branch, 1907-1909; secretary Massachusetts State branch, 1910-1911), and member of the Advisory Committee of Experts on the Carnegie Technical Schools of Pittsburg.



Photograph by Notman, Boston.

ARTHUR LYMAN WILLISTON,

PRINCIPAL OF THE WENTWORTH INSTITUTE, BOSTON

See Reverse Side.

INDEXED

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# MECHANICAL APPLIANCES FOR DUST EXTRACTION IN COTTON MILLS

By H. M. Crawford

IN the production of cotton yarn and cloth cleanliness is one of the most essential elements. And the great cotton-spinning centres of Lancashire, the West of England, and the Scottish Lowlands are now rising to the occasion of spinning a thread finer and purer than ever before in the history of the textile industry. Dirt, dust, specks and smuts are all damaging to spun yarn; and they do not fail to account for themselves unfavourably in all the succeeding operations of a mill. Clean, spotless yarns mean clean cloth of enhanced value and selling capacity.

No effort is spared in the earlier processes of cotton spinning to rid the raw fibre of much of its natural adulteration. The ginning operations in the cotton fields of Alabama, Carolina, Florida and other Southern States, while adequately clearing the cotton seeds from the general mass of fibre, leave a considerable quantity of vegetable and earthy matter mixed with it, such as plant leaf, bark, sand and gritty material. And since these are absolutely foreign to the strict requirements of finished cloth they must perforce be eliminated at the earliest possible moment.

And so bales of cotton are passed through cotton openers and scutchers, which are provided with exhaust-fan arrangements to extract the adulterants by strong air currents and pass the cotton forward in a purer condition.

But much remains to be done in the way of cleansing after the cotton has left the scutching room of an up-to-date mill. And the carding engine is the strong medium by which the cleansing process is practically completed so far as dust is concerned.

The carding machine is a sort of intermediary in the cotton-spinning process; and is, in many respects, the critical factor of the mill. It provides the first semblance of a continuous thread. The cotton reaches the carding machine, or "carding engine," as it is familiarly termed, in the form of a huge roll. This roll or "lap" is held in brackets on the back of the machine where the thick, fluffy layer of cotton is conducted by a traveling apron to the "licker-in" cylinder. This is covered with thousands of saw teeth, arranged spirally in close proximity to each other; it revolves at an extremely rapid rate, tearing the fibres asunder and depositing them on the main cylinder of the machine.

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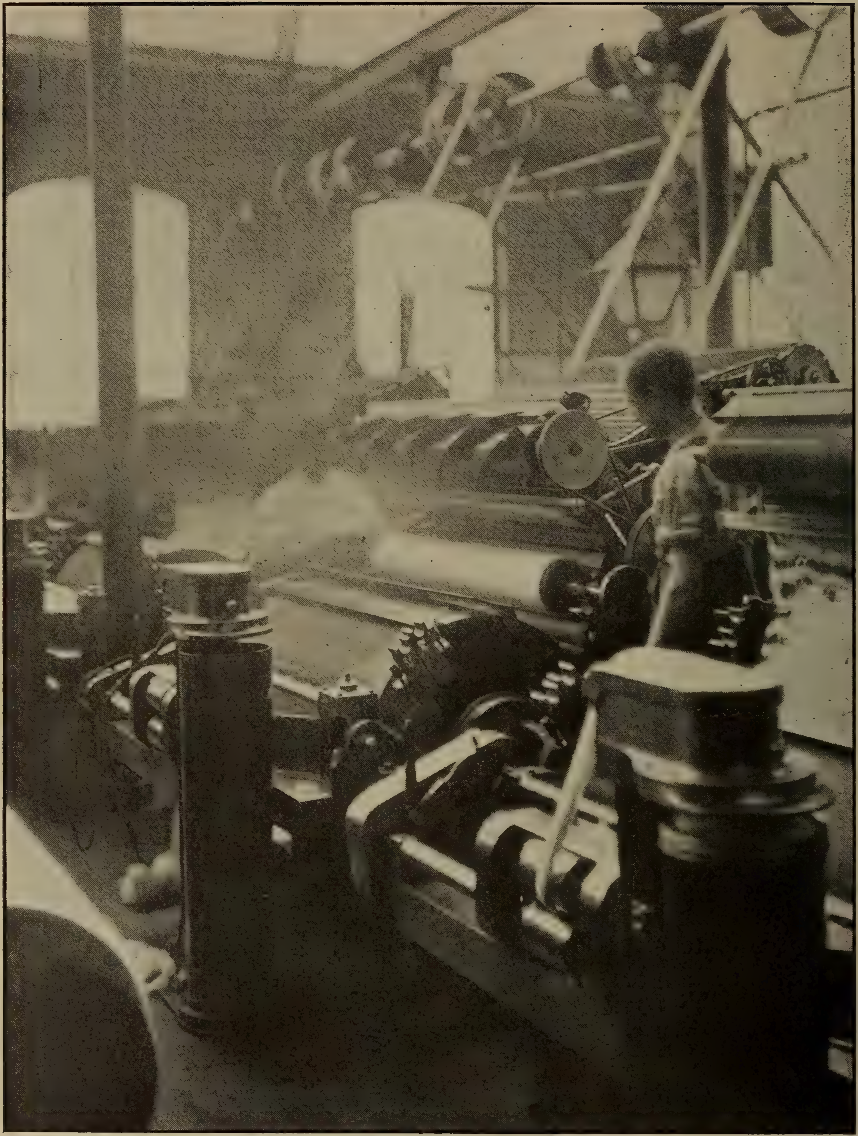


FIG. 1.—STRIPPING A CARDING MACHINE; SHOWING A DUST CLOUD

The main cylinder is belted with fillets of wire clothing, rolled round and round the cylinder so as to present a myriad of wire points to the feed of the licker-in. The fibres are thus held by the main cylinder, straightened and combed by contact with the "flats" on the upper portion of the machine. These "flats" form a series of metallic staves, each covered again with its fillet of wire-clothing; they travel at a very slow space over the upper surface of the main cylinder; and since this latter revolves at 150 to 160 revolutions per minute there is considerable combing, separating and cleansing action performed between the cylinder and the "flats."

But another important item obtains here. The wire clothing presents to the fibres of cotton from

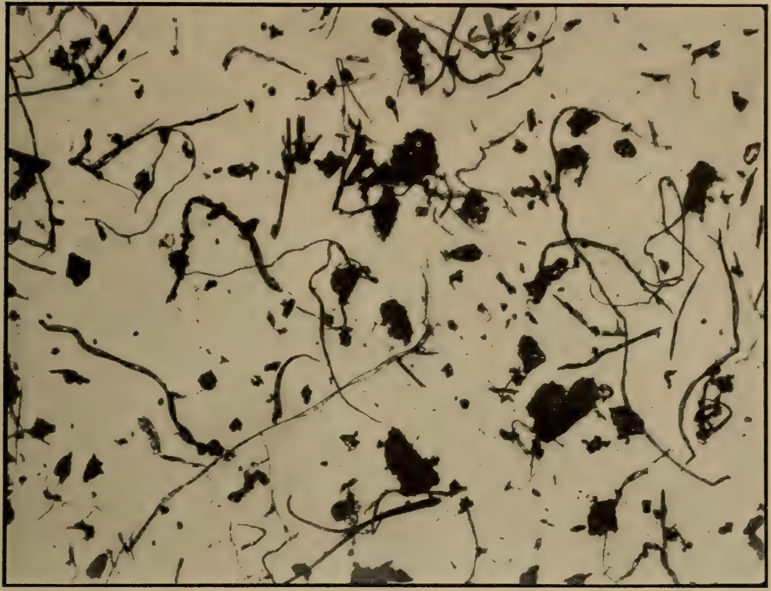


FIG. 2.—DUST GENERATED ON STRIPPING. MAGNIFIED 20 DIAMETERS

280 to 300 fine wire points to the square inch. And the opening, combing and abrading action of these wires causes myriads of dust particles and grit to accumulate between the close blades of wire, besides harbouring a vast quantity of short fibres. And as the wire blades are only about a quarter of an inch deep, it follows that the continuous use of the cylinder must, in a brief period, choke up the space between the wires and cripple the efficiency of the machine. This, therefore, brings us to the crux of our subject—the card wires must be cleansed or the factory operations must cease.

At three or four different periods in the course of a working day these card wires—both on the main cylinder and on the secondary or "doffer" cylinder — are thoroughly cleansed by the introduction of a roller stripping brush covered with wire "bristles." The brush is lodged in brackets provided on the frame of the machine (Fig. 1) by two workmen known as "strippers"; and by means of a twisted cotton band a grooved pulley at the end of the brush shaft is connected with a groove in the loose pulley on the driving shaft of the carding engine. When, therefore, the driving belt is placed on the loose pulley, and the band is slipped on the brush pulley, an effective cleansing is enacted by the brush wires piercing the interstices of the card wires. All the short fibres which clog the card wires are caught up in the brush after a few seconds' application of the latter, which makes about 200 revolutions per minute.

This liberation of short-stapled cotton does not in itself seriously involve the strippers who are in immediate proximity, as the cotton is simply transferred to the stripping brush, from which it is cleared by a T-shaped hand card. But this operation involves serious risk to the workmen from the fact that it generates a quantity of fine dust, in addition to fibrous matter (Fig. 2), forming dense clouds about the breathing area of the strippers. This item is one of great hygienic import, as it materially affects the working capacity of the stripper, and discounts the probabilities of his living a natural term of life.

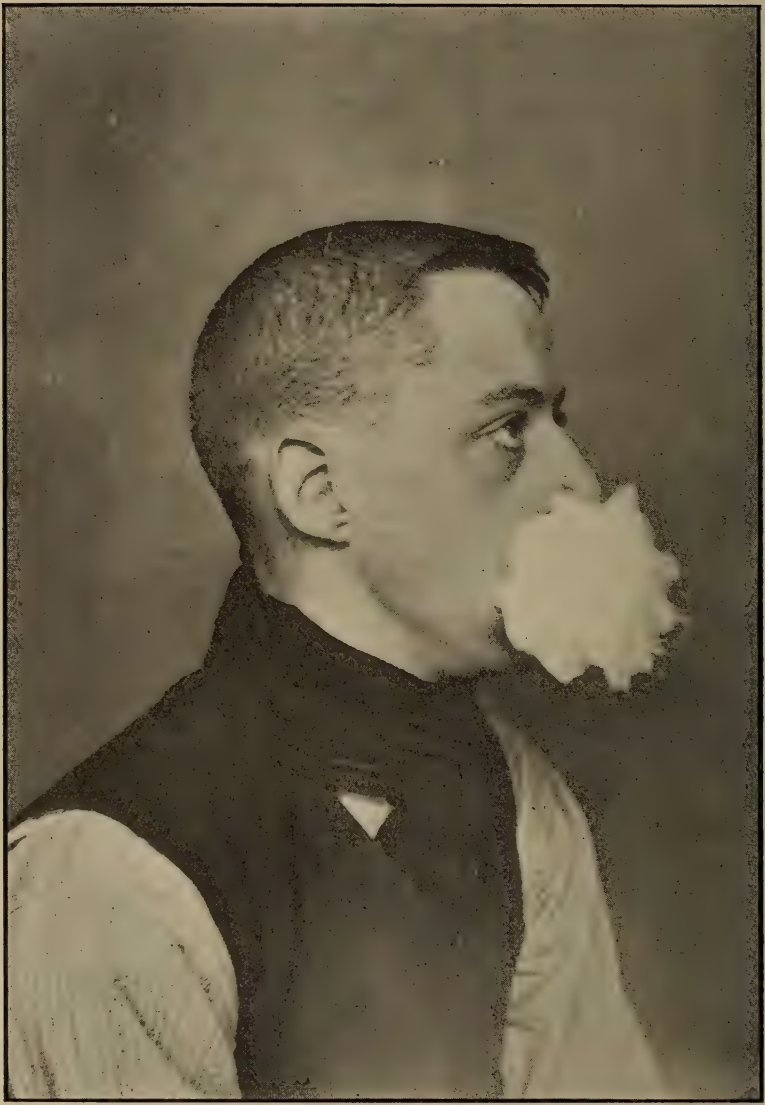


FIG. 3.—COTTON PLUG RESPIRATOR

From examinations made in various towns by local medical men a large percentage of strippers have been found to be more or less affected with chest complaints. And the average work age of men engaged in this occupation has been computed at 45 to 50.

Obviously the occasion has arisen for the engineer and the mechanician to join forces in the invention of appliances to remedy this state of affairs. For men to be disabled in the very prime of life by the evils of dust inhalation is certainly unfortunate; especially when means are devisable for the prevention of the whole mischief. The strippers, very naturally, seek relief in any direction obtainable, and for many years have adopted the homely plan of wedging a plug of cotton between

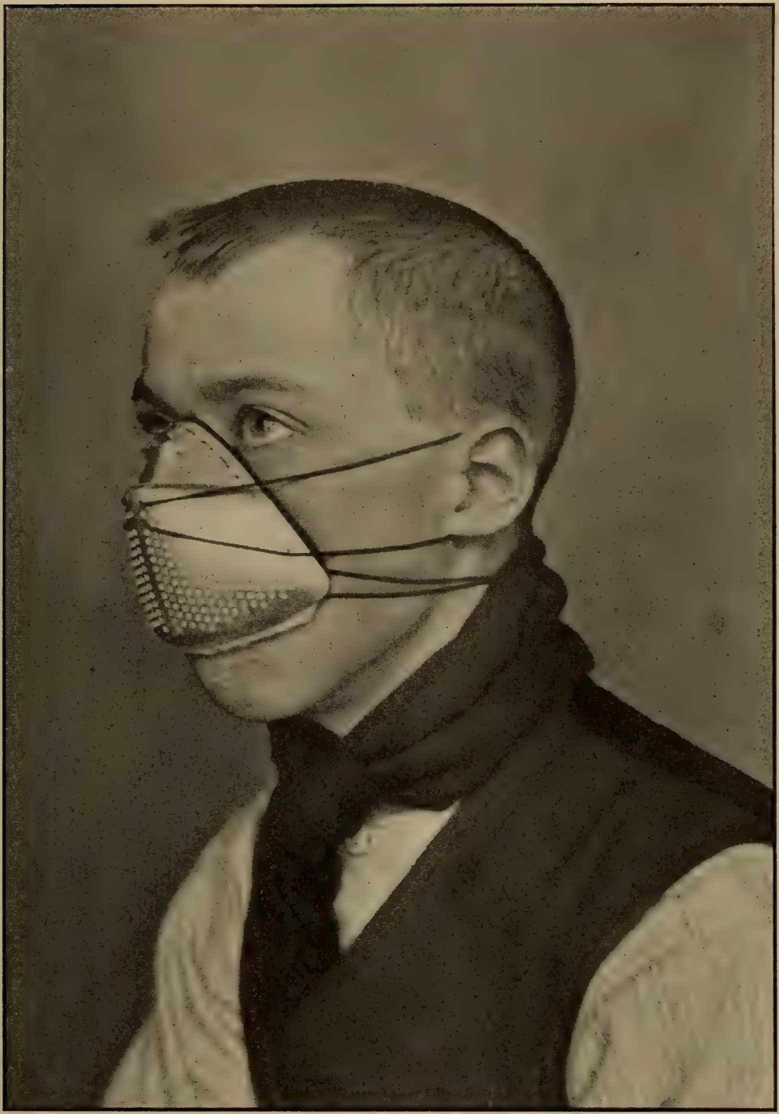


FIG. 4.—A SPECIALLY-DESIGNED RESPIRATOR

the lips (Fig. 3), in the hope of mitigating, to some extent, the effects of dust inhalation. This curious form of respirator has been used by hundreds of strippers in the Lancashire cotton mills; and from sheer custom bids fair to last sometime longer. That it has done good service is beyond doubt. In some factories other specialized forms of respirator have been used and welcome benefits have been derived from these (Fig. 4).

Efforts are now in progress for the complete elimination of the dust clouds. No such evolutions are permitted to escape into the card room of the mill. As rapidly as the dust is generated in the carding machine it is caught up into trunks or tubes and conveyed away to external parts of the mill by powerful extracting

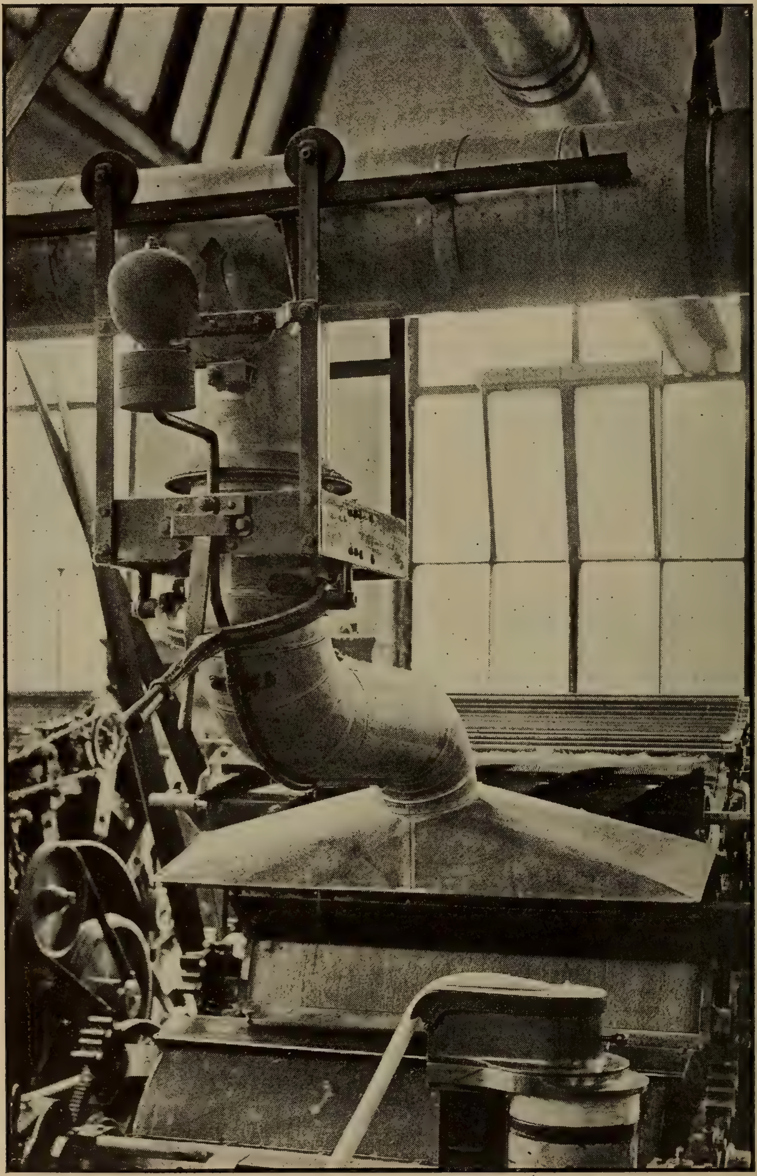


FIG. 5.—AN EARLY FORM OF DUST EXTRACTOR, WITH HOPPER AND MOVABLE CARRIAGE

forces in the shape of fans or steam vacua. The purification of air and elimination of dust have been treated heretofore by the location of exhaust fans in windows or walls of the room. But while this system promotes to some extent a displacement of impure air, it does not remove the dust and cotton "fly" until these materials have passed over the area of the room, or some part thereof. The "fan in the window" diffuses the dust before clearing it away.

If then the problem of dust extraction is to be properly solved, means must be adopted to catch the dust particles as near as possible at the line of their evolution, where the stripping brush impinges on the card cylinder. An early effort (Fig. 5) made in this regard proved it to be the remedial line of action. An appliance was designed to cover the space immediately above the stripping brush by a full-sized hopper, with trunk connected to an enclosed exhaust blower erected on a girder of the mill. The blower was turned directly from the line shaft at a speed of 1,500 revolutions per minute, and created a draught which left no doubt as to the possibilities of extracting dust from carding engines.

Further progress resulted in the production of a swing hopper adopted to each line of cards and so levered that it could be applied to either the main cylinder (Fig. 6) or the doffer (Fig. 7) of the carding machine. One hopper thus suffices for some

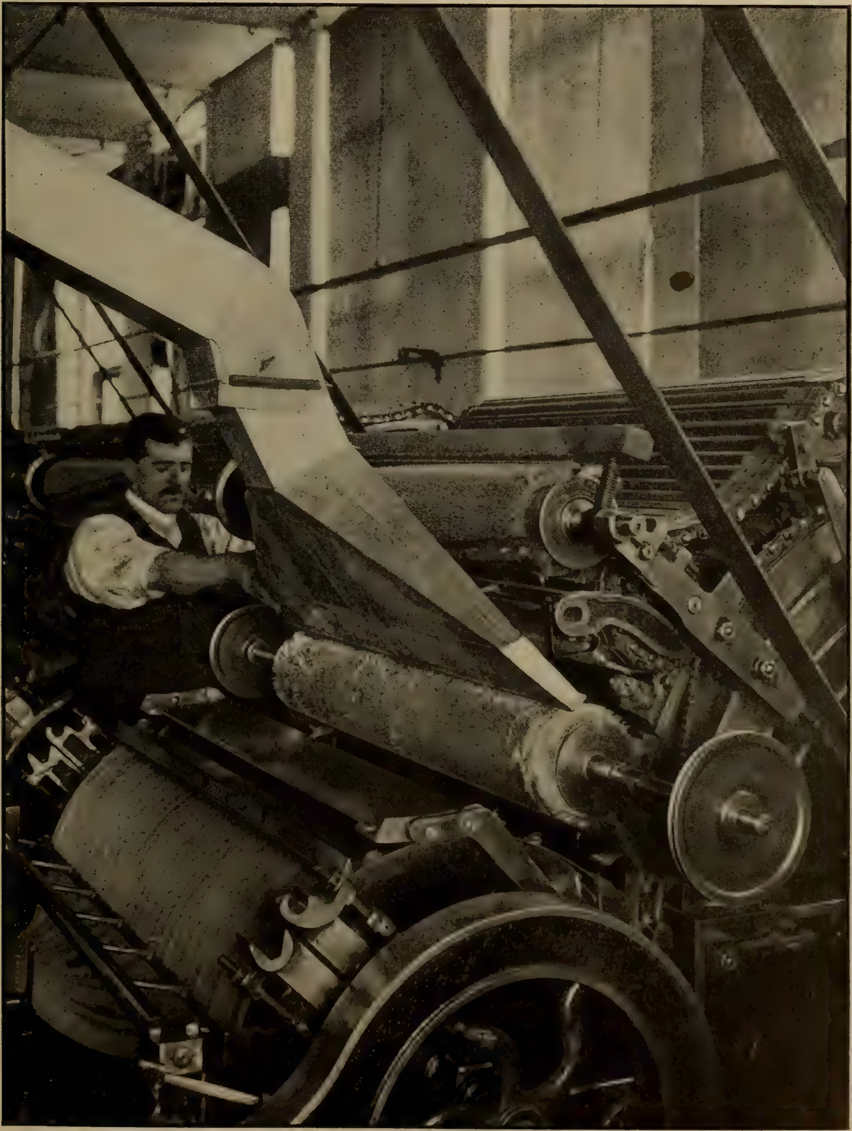


FIG. 6.—PIONEER DUST EXTRACTOR AS USED IN STRIPPING MAIN CYLINDER

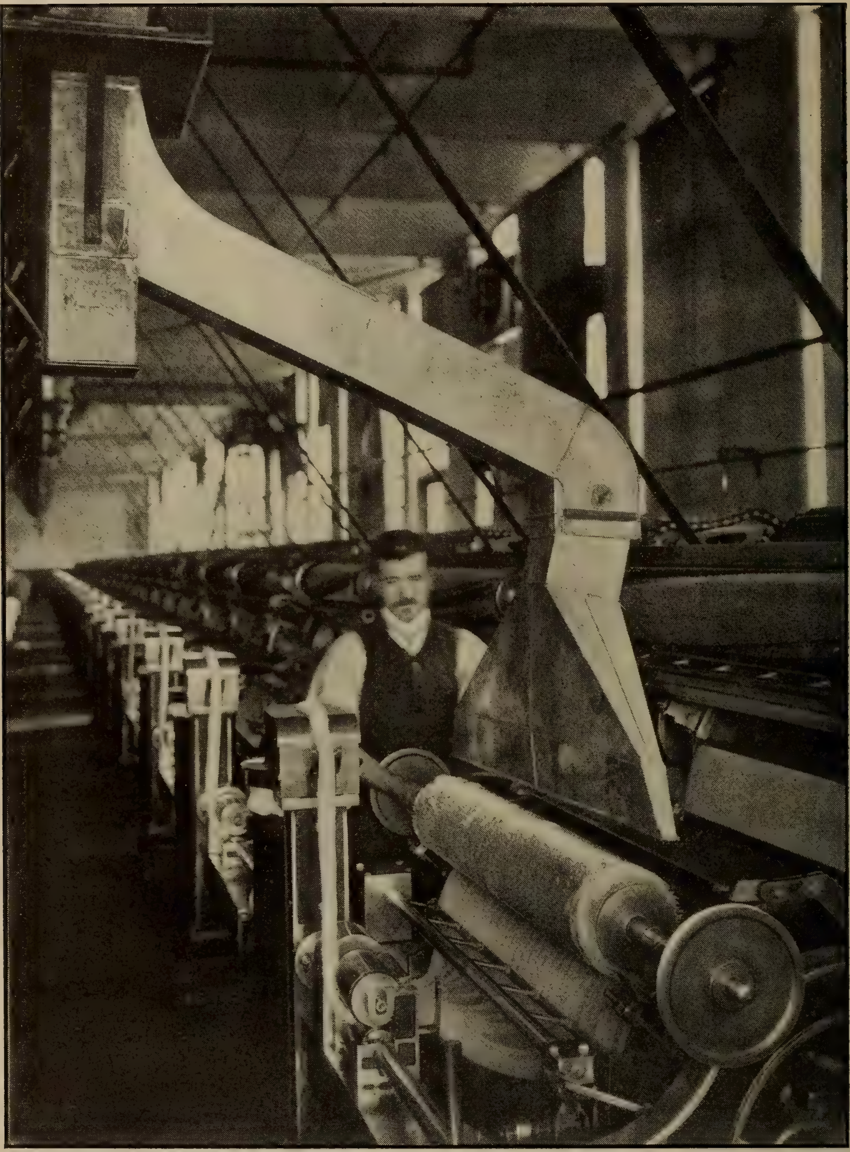


FIG. 7.—EXTRACTOR AS USED FOR DOFFER CYLINDER

twenty or thirty cards, according to the length of the line. The hopper is fixed to a movable carriage (Fig. 8), which, by grooved pulleys, runs on side rails attached to the dust trunk.

The operation of this extractor—the "Pioneer"—will be readily understood. The strippers place the brush in position and draw the hopper immediately over the dust-generating line. At the moment the extractor is placed opposite the card under treatment, a valve on the dust trunk is automatically opened, and the fan current begins to draw off the dust as it is generated. The exhaust fan (Fig. 9), about 15 inches in diameter, and making 1,600 revolutions per minute, is erected in the main trunk as nearly as convenient to an external dust chamber. When a card has been completed and the extractor is moved forward, the trunk valve automatically closes. By this means the exhausting force is concentrated on each card in succession.

For the purpose of general ventilation, that is, an interchange of the air of the room when stripping is not in progress, arrangements are made for opening a number of valves on each trunk line.

In an early installation of the "Hall & Kay" extractor (Fig. 10) flat receivers, the width of the carding machine, and about 2 inches across, depend from the air trunk, and are opened or closed at the will of the operator by means of patent balanced lids. In a later type (Fig. 11) the flat receiver gives place to a cylindrical body and a triangular receiver with 2-inch aperture and balanced lid as before. This body allows of greater light penetration in the room, and may be detached as shown in the illustration from the air-trunk brackets. The aperture in this installation opens just over the

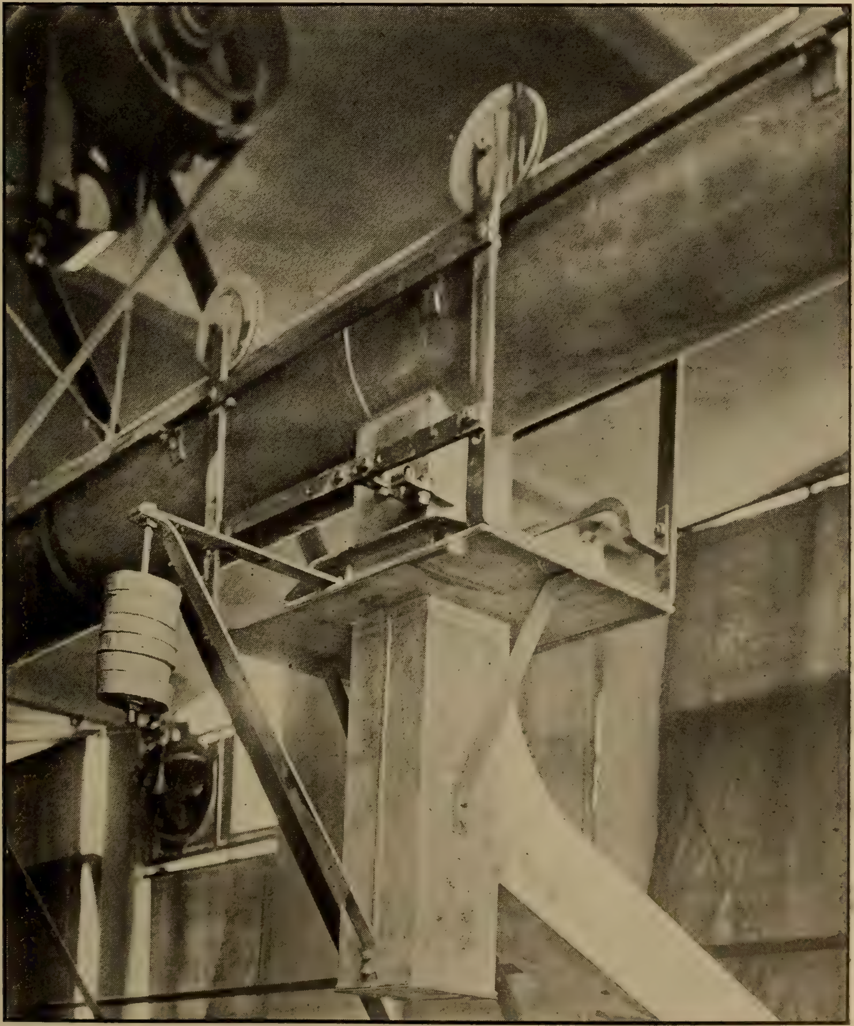


FIG. 8.—DUST HOPPER ON MOVABLE CARRIAGE

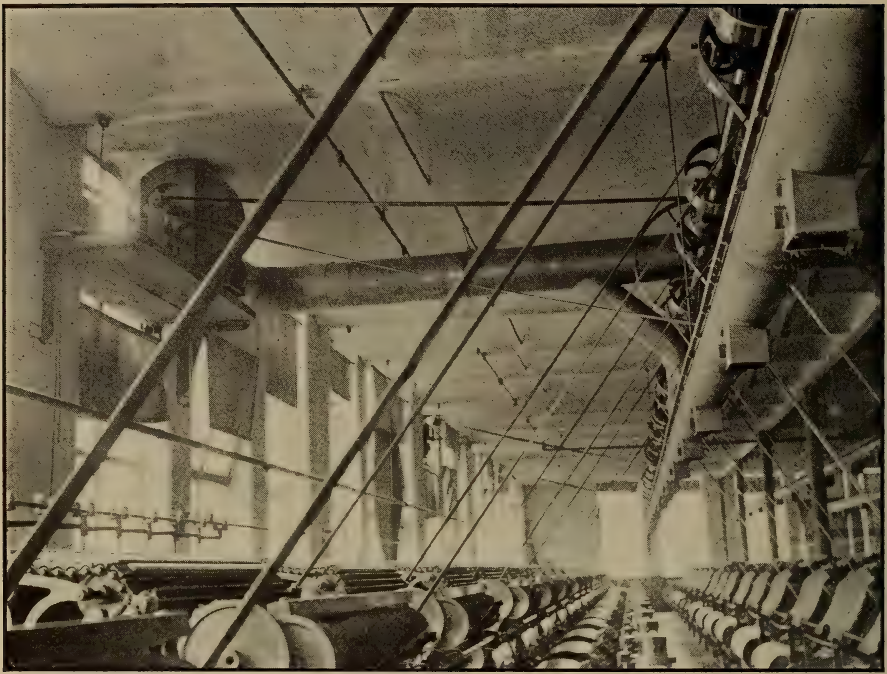


FIG. 9.—EXHAUST FAN (NEAR THE OUTSIDE CHAMBER) AND DUST TRUNKS

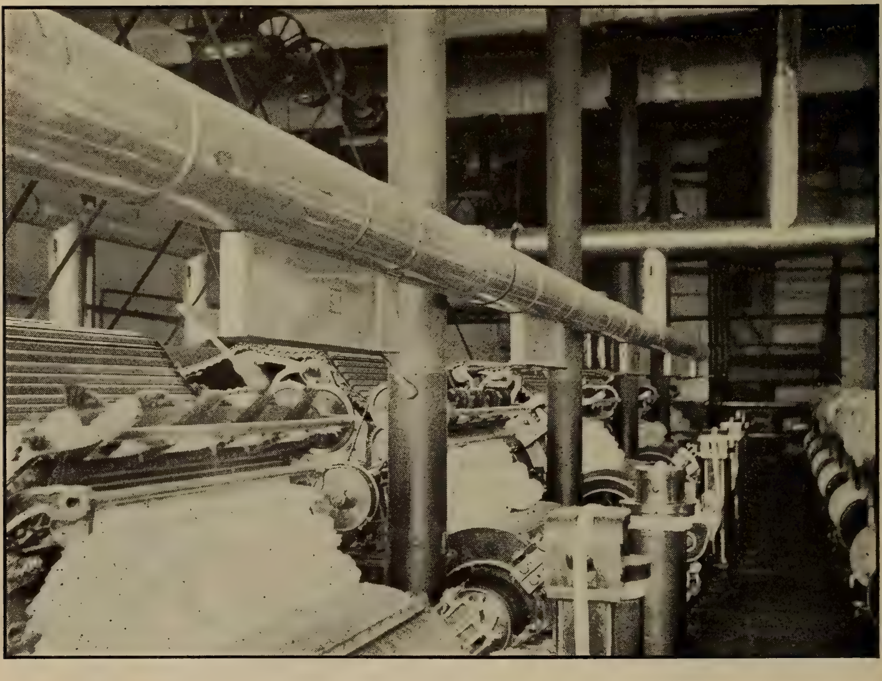


FIG. 10.—A LINE OF FIXED DUST REMOVERS OVER CARDING ENGINES

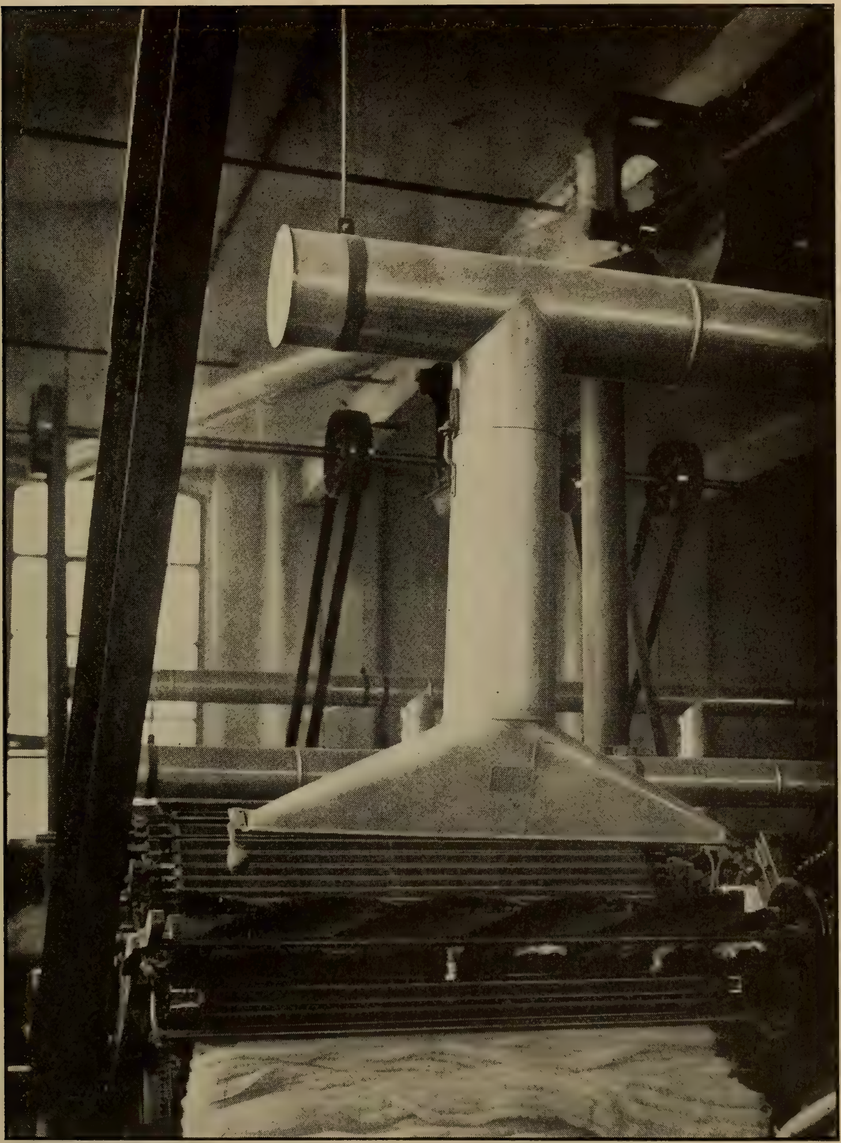


FIG. 11.—DUST RECEIVER WITH CYLINDRICAL SHAFT

comb brush of the carding machine, and gradually widens to the diameter of the vertical shaft.

Further experiments have resulted in additional improvements (Fig. 12), whereby the air trunk is fixed nearer to the ceiling, the shaft lengthened and reduced in diameter, and the receiver inclined inwards so as to exhaust the stripping dust at its line of origin. The junctions of the shafts with the air trunks are also inclined, so as to minimize any obstruction to the current from sharp angles. In Fig. 13 will be seen the receivers in position over five carding machines, and the various branch pipes connected to the main duct. In working the extractor all apertures are closed except the one over the card being stripped. The fan exhaust is then concentrated on this, and the dust visibly passes into the receiver. At intervals in the main air trunk small ventilators are inserted, each with its own balanced lid, for the express purpose of ventilation as distinct from dust extraction. Thus, after the card stripping is finished, two or more of these apertures may be opened for any length of time desired by the operatives.

The "Gregson" system embraces a vertical air shaft for each carding machine; and on this a patent swivel hopper is fitted so as to adapt the receiver to either main cylinder or doffer. A sliding shutter, shown at *A* (Fig. 14), in the air shaft allows

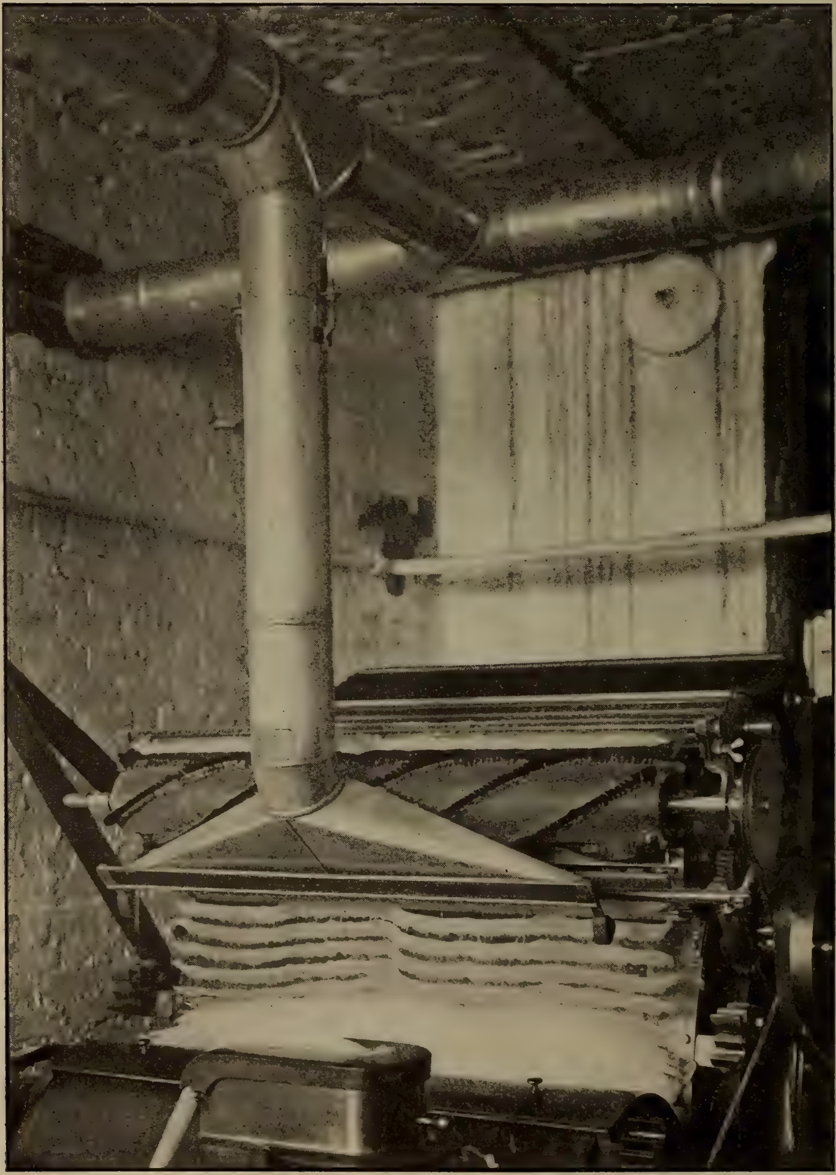


FIG. 12.—HALL & KAY DUST EXTRACTOR ON CARDING ENGINE

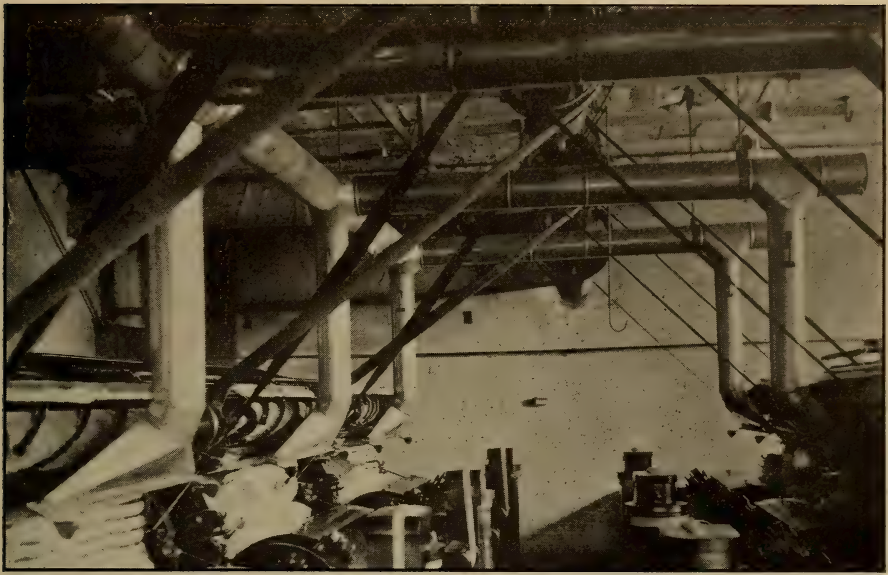


FIG. 13.—DUST EXTRACTORS OVER TWO LINES OF CARDING MACHINES

the operator to open the exhaust when commencing to strip the card and to close it immediately the work is finished. The receiver in this installation covers the back and front portions of the stripping brush, as shown in Fig. 15. Any shutter in the series may be opened to allow of interchange of air for ordinary ventilation. This condition is also admissible in the event of the card cylinders being reground by means of

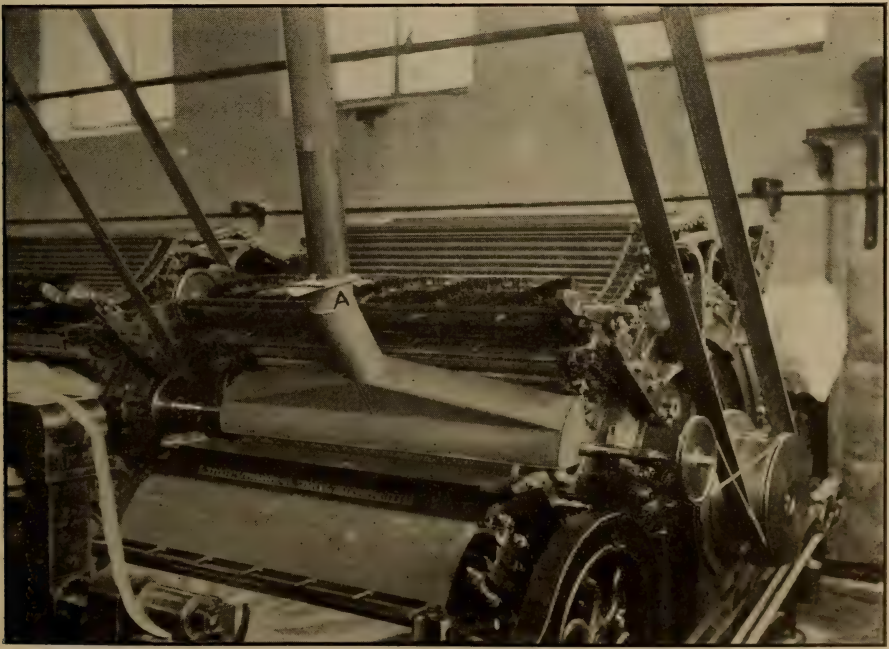


FIG. 14.—GREGSON EXTRACTOR IN USE OVER MAIN CYLINDER, WITH SLIDING SHUTTER AT A

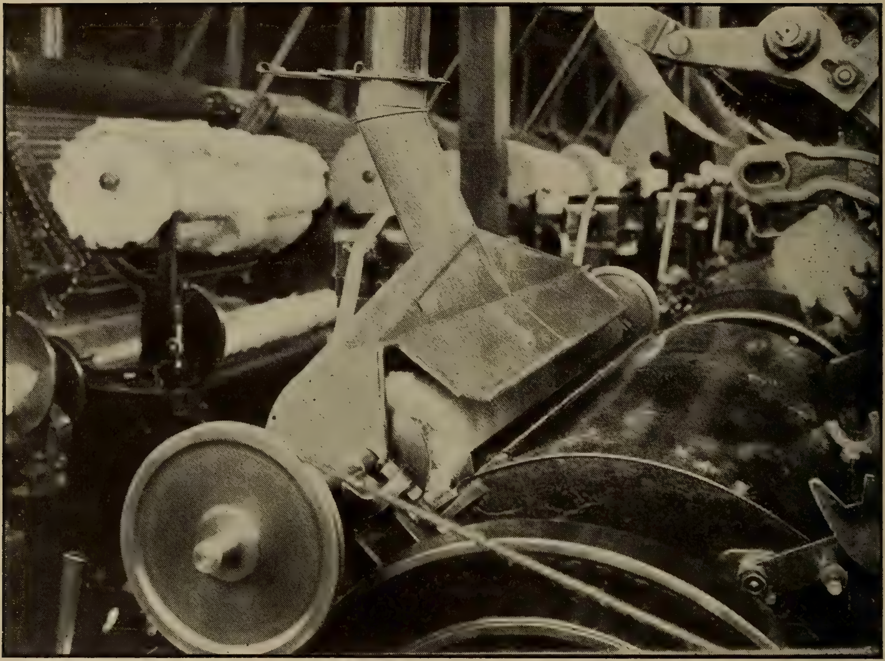


FIG. 15.—EXTRACTOR WITH BACK COVER OVER STRIPPING BRUSH

revolving emery wheels (Fig. 16). The process of regrinding does not generate a considerable amount of dust, but this is, bulk for bulk, more injurious than stripping dust owing to its metallic nature. When the hopper shaft is opened the finer particles are drawn within the range of

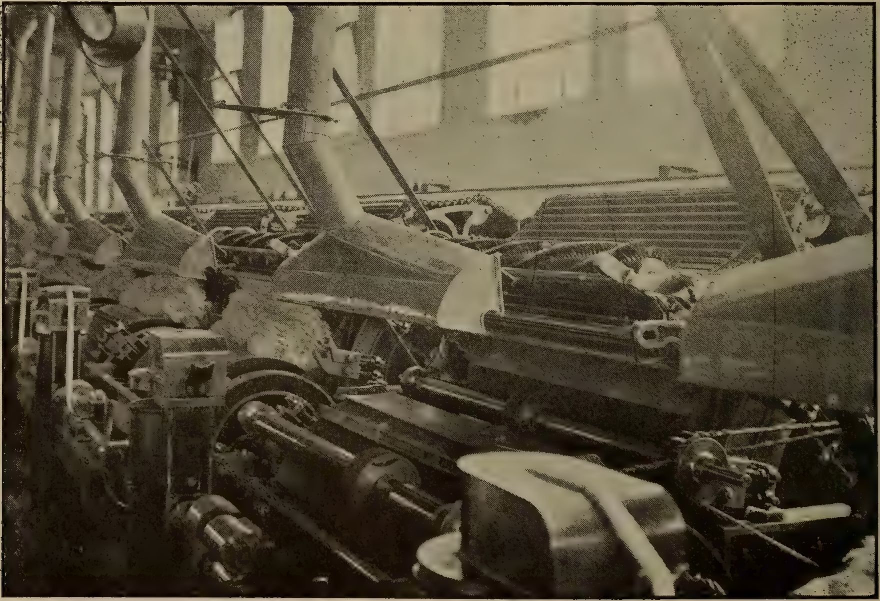


FIG. 16.—EXTRACTOR IN USE DURING GRINDING OPERATION

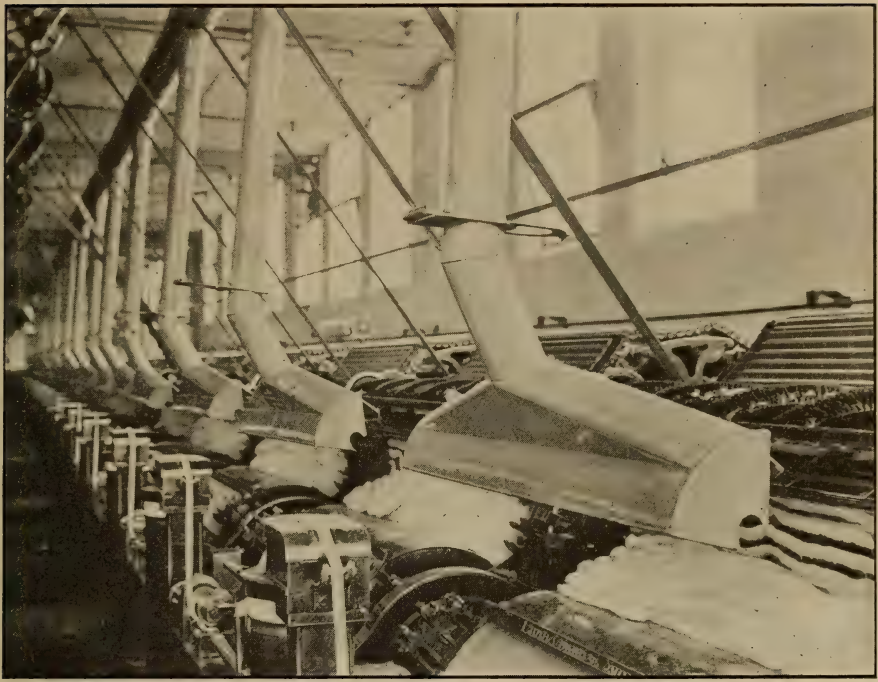


FIG. 17.—SERIES OF GREGSON EXTRACTORS

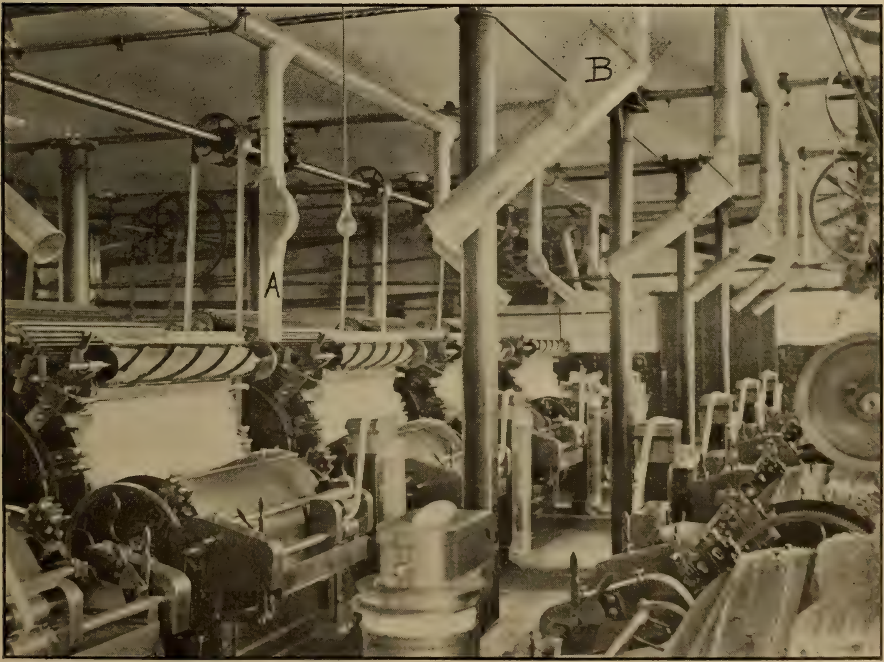


FIG. 18.—TUBES IN REFORM SYSTEM OF DUST EXTRACTION (VALVE AT A IS OPEN)

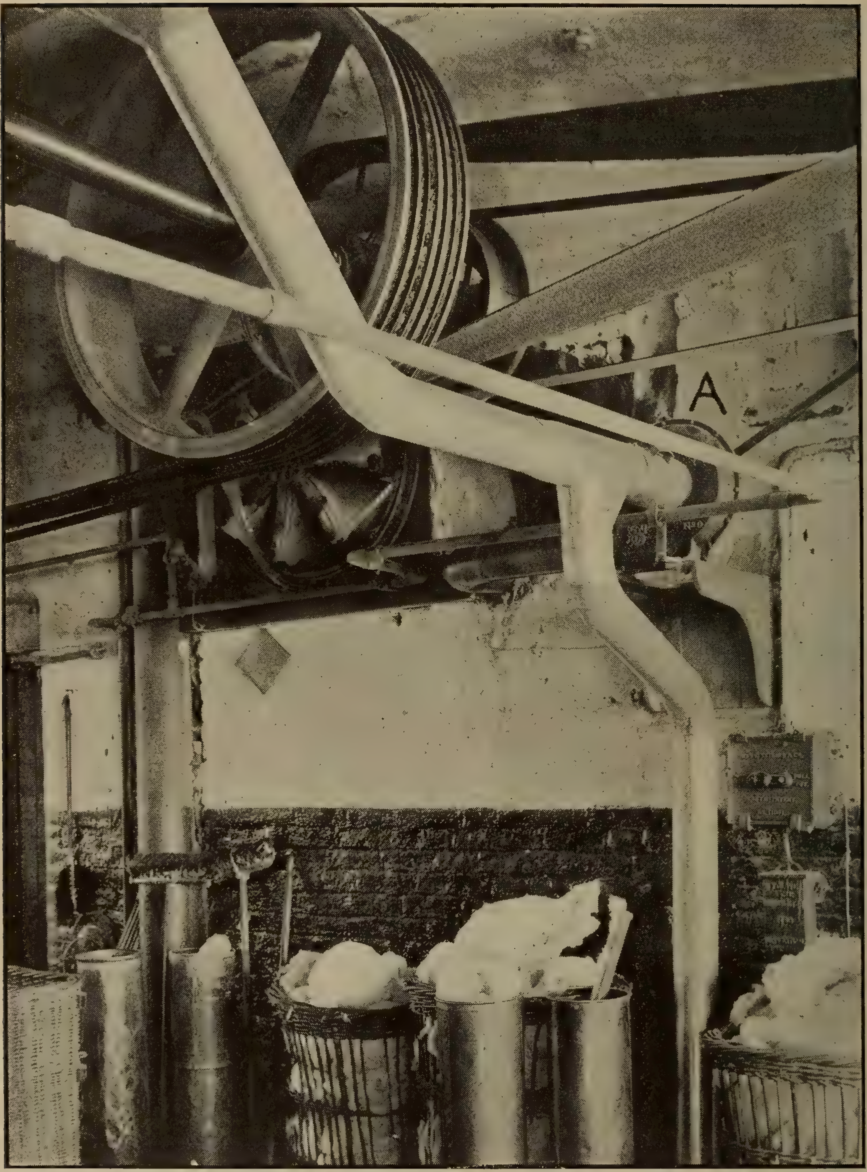


FIG. 19.—FAN AT A OPERATING ON TWO SERIES OF TUBES

the ventilator; the heavier deposit settles in the region of the grinding roller and is, therefore, innocuous to the workman. The air shafts pending over each machine are varnished a light tint, so as to reflect daylight; thus the general illumination of the room is not materially affected (Fig. 17).

The "Reform" system of dust extraction is in vogue in several cotton mills. As illustrated in Fig. 18, it consists essentially of horizontal branch pipes attached to the ceiling over the lines of carding machines. These branch pipes lead into a main trunk, where an enclosed fan of about 12-inch diameter is operated by a belt from the overhead driving shaft. From these horizontal pipe lines a vertical tube extends over the centre of the front of each carding machine. Each tube is cylindrical, of about 4-inch diameter, and contains a patent-hinged joint, with a valve which is opened or closed by the position of the fixed tube. When, for example, the tube is vertical the valve is fully open, as at *A* (Fig. 18), and may be used for exhausting the ordinary air of the room. When the tubes are bent to their full limit, at about 45 degrees, the containing valves are closed, as shown at *B* (Fig. 18). It thus follows that when all the tubes are flexed, any one may be opened and used for the purpose of stripping by straightening and connecting it to the stripping brush. Then the full force

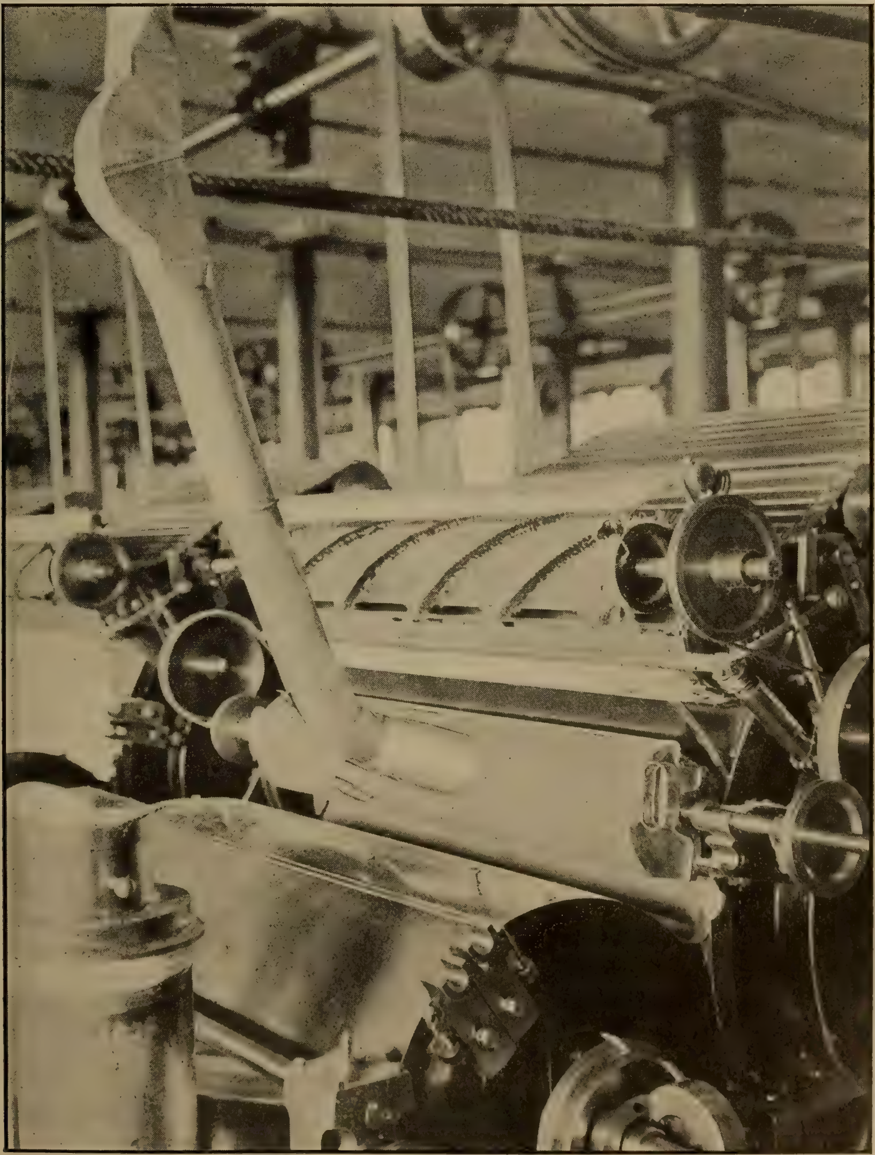


FIG. 20.—EXTRACTOR USED OVER MAIN CYLINDER

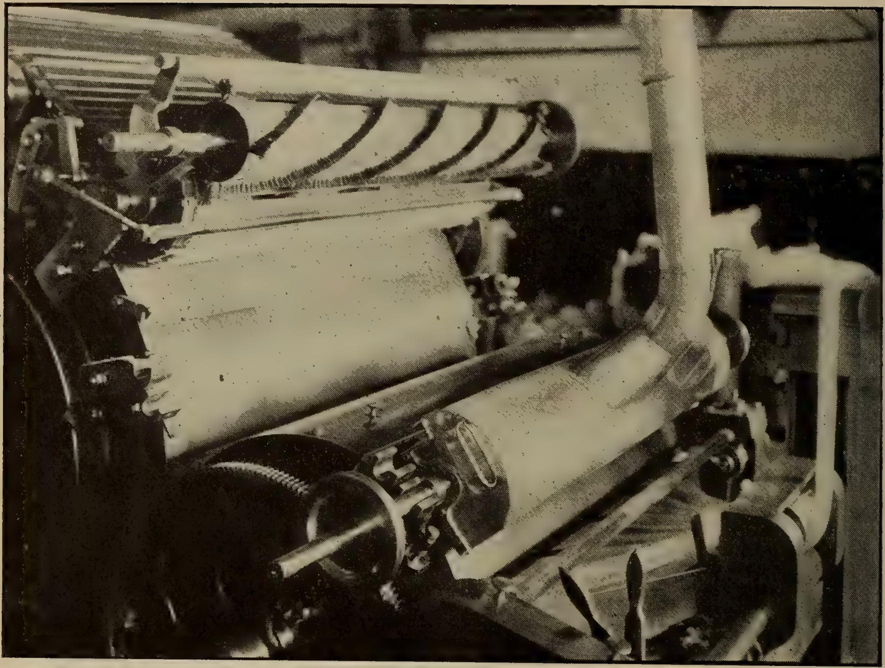


FIG. 21.—DUST EXTRACTOR OVER DOFFER CYLINDER

of the fan current will be exerted on the one or two cards under treatment. It is possible to deal with three or more machines simultaneously by increasing the extracting force of the fan. It has been found that a 12-inch fan (Fig. 19) will accomplish the work desired on forty machines, allowing two to be stripped at the same moment.

The method of adapting this extractor is seen in Fig. 20, where the stripping brush is applied to the main cylinder of the carding machine, is covered with a hood of aluminium and connected to the vertical tube. For facility of porterage, handles are fixed to the extremities and front of the hood. It will be clear that the exhaust force begins at the moment the lower tube is fitted to the upper; hence dust is extracted from the moment it is generated, that is, when the driving band is slipped on the grooved pulley at the end of the brush shaft. No dust is thus allowed to escape. Fig. 21 shows the same hood in use over the doffer cylinder.

Most spinning establishments have their dust chambers where the refuse from cotton openers and scutchers is regularly deposited. The dust from carding machines may be conducted thither also, by connecting the fan trunk to the chamber. Or the dust may be passed into a cyclone funnel, which will permit its gradual deposition into any receptacle that may be placed under the funnel.

In thus clearing the atmosphere of the card room by mechanical means a potent effect is undoubtedly given to the quality of the spun yarn. When the dust and short fibre is allowed to diffuse throughout the room it must, of necessity, settle largely on the various machines—speed frames, draw frames, combers—and on the material passing through them. And where coarse counts of cotton are dealt with the mischief becomes more pronounced. The benefits obtainable are demonstrated daily in their twofold aspect—the commercial advantage to the employer and the health of the operative.

# THE FORMATION OF PETROLEUM ACCUMULATIONS

By Wilbur Greeley Burroughs

DOWN in the earth sometimes a few thousand feet, sometimes seeping out at the surface, is a liquid varying in colour and density and possessing a high commercial value.

Great fortunes have been made by the discovery of this fluid—petroleum; great fortunes have been lost in vain search for its hidden reservoirs.

Even to those who have spent their lives in the oil business, prospecting for petroleum and the opening up of new areas of oil-producing land is purely a gamble. Occasionally a man wins, and the golden harvest he reaps is indeed bountiful; but by far the more common case is that he loses, and loses heavily.

Take, for example, the following true instance of a man whom we will call Brown. He had been in the oil business for most of his life and knew it thoroughly. Brown, with his associates, had 500 acres north of Tulsa, Okla., in what is known as the Flat Rock Oil Pool. They paid $50 an acre bonus, and this, with their operating expenses, made their aggregate investment from $30,000 to $40,000. Their wells struck oil in quantity, and inside of a year they sold out for $250,000.

In October of the autumn of 1909 an oil man named David Gunsberg leased some land near Hamilton Switch, Okla., at $5 an acre. He drilled one well on his property which showed oil in great volume. His total investment amounted to about $5,000. On word going out of this new oil strike a wild rush of speculators commenced. The trains were crowded with men, all eager to take up land. Inside of a few weeks a town had sprung up at the Switch, where before had been the peaceful prairie. Other wells were drilled, but without much success. The oil soon gave out, and nearly all the investors in Hamilton Switch lost money heavily, including Brown and his associates, who had previously done so well in their Flat Rock deal.

This instance is cited to show more clearly the uncertainty of investing in land which has not already been thoroughly proven to yield petroleum. It is not an exceptional case, but has been repeated hundreds of times. Often where a number of wells will be yielding large quantities of oil on one property new wells drilled only a few yards away will fail to strike petroleum. The reason for this will be clear when one understands the manner in which the oil is stored in the rocks; but first let us consider what precautions can be taken so as to make an investment in an oil field as secure from loss as possible.

All professional oil men agree that the only safe way, especially if one is not familiar with the petroleum business and the particular field in which he wishes to place his money, is to go in on a basis of the amount of production per day of wells already drilled on the property in question. It is best that these wells be scattered over the tract of land which one wishes to buy, so that the entire property will be thoroughly proven to contain oil. Also, the more wells the better, for the greater will be the value the purchaser receives in equipment. The wells should have a settled production—that is, they should have been pumped long enough to have let the first spurt of oil which occurs from a well being shot to have subsided. This first rush of petroleum is due chiefly to the pressure of gases, or of water in the rocks below the oil, which, relieved of the confinement under which they have been subjected, escape to the surface, carrying up the oil in unusual quantities.

A well one or two years old will have a good, steady yield. An average for about ten days of the output of petroleum for the entire property should be taken. In reckoning this the yield of all the producing wells on the land is added together, constituting the output for the property. Another method is to take the yield on the tenth day of the investigation, the wells being pumped continuously for the preceding nine days.

The prospective purchaser or investor now should take into consideration the structure of the oil field and the length of time the oil-sands of that field, as a rule, continue to produce; and, knowing the price per barrel of crude oil in that field, an approximate value of the property can be obtained.

Caution should be used in buying land which is not at present producing and the petroleum being marketed. Take no one's word, or even oil records, as proof that the wells had been yielding a good supply of oil, for these oil records are often juggled and changed into recording anything but the truth. Pipe-line statements for an extended period of several months are, however, trustworthy as a basis of valuation for the property, though the actual pumping of the wells before one's own eyes is the best method to use and should be taken into account along with the pipe-line records.

Salting of wells has been accomplished by hauling petroleum and pouring it into dry wells. Then the prospective purchaser would have a little baled out as proof that the well contained oil. To safeguard one's self against this ruse, have the well baled or pumped for quite a number of hours, when, of course, it will run dry if it is a fake proposition.

### SURFACE INDICATIONS OF PETROLEUM

There are surface indications of petroleum common to all oil fields in general: (1) A seepage of oil, which is the surest sign of its presence. This must not be confounded with the iridescent scum of iron oxide, which often occurs on stagnant water in a country where the soil is strongly colored with oxide of iron. This particular iron oxide, formed by a combination of iron and the gas oxygen, is of a reddish-brown colour, and is the material which usually makes soils of a red hue.

(2) At shallow depths a black asphalt is sometimes found in the soil. This is left on the evaporation of the more volatile parts of the petroleum.

(3) The most common of evidences is the escape of gases, for petroleum always has gas associated with it. If the gas is rising through water, notice whether or not the gas bubble, on breaking, leaves a film of oil. Everyone is probably familiar with the rainbow-tinted scum floating on top of water, which is caused by even a drop or so of oil. If this film of oil is not formed, petroleum will not be below, as the gas bubble contains no trace of oil. But if it did form, petroleum in paying quantities may not be below, as a small, diffused amount of oil could furnish that in the bubble. Oil does not always occur where gas is; the gas always occurs where oil is.

(4) The escape of a gas called hydrogen sulphide, which smells like rotten eggs and gives the characteristic odour to springs of sulphur-water and what is known as "sour waters," are phenomena often occurring in oil fields. In the petroleum field near the Gulf of Mexico oil often has accumulated in large quantities under low mounds.

### ORIGIN AND ACCUMULATION OF OIL.

Having gone over all the precautions which the investor can make for himself above ground, let us see what dangers beset his money underground—why it is that when oil is struck in one place another well, even a few yards distant, may be dry. We will begin at the beginning, for every step in the process of the accumulation of petroleum has an important bearing on whether or not the investor in an oil property becomes wealthy or loses all he put into the venture.

The origin of petroleum is everywhere the same. Of the many hypotheses advanced, the organic origin of petroleum is based on the soundest geologic facts. No matter where sediments—such, for example, as mud, sand etc.—are deposited if they enclose animal or vegetable matter petroleum may be produced; but a few other factors are necessary in order that the transformation from organic matter to petroleum will be more certain to take place. These factors are water, preferably salt, which must be present, air must be excluded, and a layer of clay must cover the material from which the petroleum is being formed. This covering of clay is necessary in order that the petroleum be kept from rising, diffusing itself in the strata above, and finally escaping at the surface of the earth. It does not rise through the clay, because the pore spaces are too minute to allow circulation of a liquid. The change which takes place in the making of the petroleum from the animal or vegetable material is accomplished by a process of slow distillation of the organic matter.

After the oil is once formed, in order to obtain it in paying quantities it has to be moved by water, gases or gravitation and accumulate in porous rocks or cavities under layers of non-porous material. The most common kinds of rock in which petroleum gathers, awaiting the time for the drill-hole of man to set it free, are sandstone, a rock formed by cementing sand grains together; conglomerates, which are composed of broken and worn pieces of other rocks cemented together; sand; gravel; dolomitic limestone, a kind of limestone containing magnesium and more porous than ordinary limestone; sandy shales, a compressed, compact and cemented mud and sand. Less common reservoirs are such rocks as flint, slate, shale, graywacke and crystalline schist.

The structure of the rock is still another item of vital importance in this chain of events which begins with a buried animal or plant and ends with the running of an automobile by gasoline (a distillation product of petroleum) and numerous other uses to which this remarkable liquid is put.

### OIL ACCUMULATED IN ROCK WAVES AND TROUGHS

Ages and ages ago the layers of rock (strata) in certain regions were compressed due to the shrinking of the earth, and folded into the form of waves similar to waves seen on an ocean or lake. Sometimes these waves were enormous, covering great areas; in other places they were small. Often there would be large waves, with smaller waves on the flanks of the large ones.

The rocks which everywhere underlie the surface of this sphere on which we live are filled with water. In some regions this water may be near the surface, thoroughly saturating the strata; in other regions this "ground water," as it is called, is hundreds of feet below the surface. The petroleum derived from animals or plants is forced upwards in the porous rocks by this ground water, upon which it floats. Where the pore spaces in the rocks are full of water the oil will be forced upwards toward the crests of the rock waves. (See Fig. 1.) Gas generated from the oil being lightest, will rise to the very top of the wave, where, in order for an accumulation of oil and

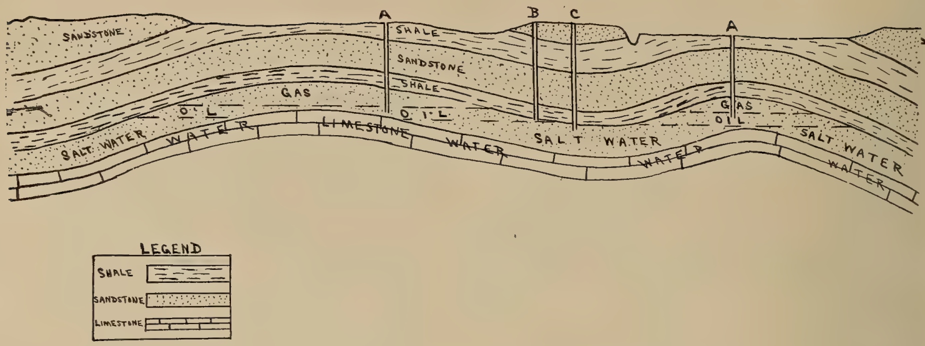


FIG. 1.—SECTION SHOWING OIL ACCUMULATED IN ROCK WAVES

The height at which the oil will be in the wave depends on the water beneath the oil. Wells *A, A* struck gas and oil; well *B* struck oil; well *C* yielded only water.

gas to take place, the overlying rocks must contain such minute pore spaces that the gas, oil and water cannot pass through it. Next below the gas will come the oil, and below that the water which fills the rocks. Thus the oil will occur near the crest (anticline) of the rock wave, in the trough (syncline), or at some intermediate point, depending on the height of the water filling the rocks. Consequently, before drilling a well in a region where the strata are folded, the exact structure of the rock and the depth of the ground water beneath the surface should be ascertained, so as to know whether to drill near the top of the wave, in the trough, or at some place between. This is acting on the supposition that the porous rock is continuous over the entire rock wave. If the porous rock is only in patches, called lenses, the oil would rise only in each isolated porous area as high as the ground water floated it and the pore spaces permitted.

We are all familiar with the occurrence of small waves on the sides of large ones in the ocean or our larger inland lakes. So it is with these rock waves; the rock fold may not form a continuously smooth wave, but it may be irregular on the sides, forming terraces (see Fig. 2) or minor folds. The gas and oil, in rising, would collect below these lesser waves of underground rock.

As a general rule, rock waves extend for a considerable distance, and both the rock folds and the rocks composing them are uniform over this area, so that in prospecting for oil in a region like this just described the chances of success in finding petroleum are far better than in any other way in which oil accumulates.

In the United States the oil fields where the petroleum occurs in rocks which have been folded into waves are: (a) The Appalachian field, extending from Western New York in a southwest direction along the western side of the Alleghany Mountains through Pennsylvania, Eastern Ohio, West Virginia, into Kentucky and Tennessee. The rocks containing oil in this field are principally sandstones.

(b) The Lima-Indiana field includes the northwestern part of Ohio and a strip in the middle of Indiana. The petroleum occurs mainly in dolomitic limestone.

(c) The oil field of Southeastern Illinois is a third instance of the structure under consideration. The oil rocks are generally sandstones or sandy shales.

(d) In the California petroleum fields one of the modes of accumulation is in the above-mentioned rock-wave structure. But the California

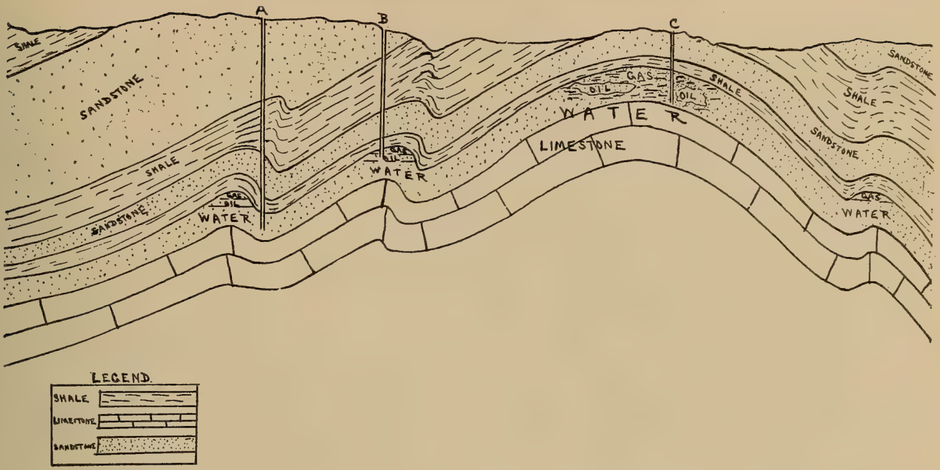


FIG. 2.—SECTION SHOWING OIL IN THE MINOR FOLDS OF A LARGE ROCK WAVE AT WELLS A AND B

Well *A* missed the gas and oil, striking water; well *B* obtained gas and oil. Near well *C* the gas and oil have accumulated in the porous sandstone, which is surrounded by shaly sandstone having less pore space. Well *C* missed the oil, which it would not have done had the sandstone been uniformly porous, as in Fig 1.

fields have numerous other ways in which oil has lodged, and which are absolutely hidden from man save by drilling, and then the chances of finding the oil are unfavourable.

(e) Other important examples of this manner of oil deposit are found in Colorado, Alaska and the Wyoming oil fields.

### PETROLEUM IN ROCKS OF LENS-SHAPED STRUCTURE

Oil is obtained in regions where the rocks are not folded. It has accumulated in disconnected lenses or beds of sandstone surrounded by shale (see Fig. 3). This form of oil deposit makes the striking of petroleum extremely hazardous. Wells drilled a few rods from producing wells have failed to obtain the desired prize. Also, where new lenses will occur can only be known by actual drilling. There is one theory set forth in the United States Geological Survey Bulletin, No. 340, which throws light on the future development of the Midcontinent field, comprising Southeast Kansas, Oklahoma and Northern Texas, in which this form of oil deposit is the most important. It is that these patches of

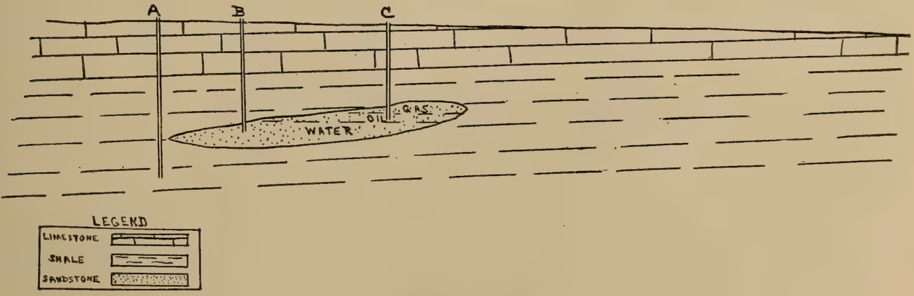


FIG. 3.—PETROLEUM IN POROUS LENS-SHAPED ROCK

Well *A* missed the lens; well *B* found the lens, but yielded only water; well *C* struck gas and oil. Gas occurs at the highest portion of the lens, oil below the gas, and water beneath the oil.

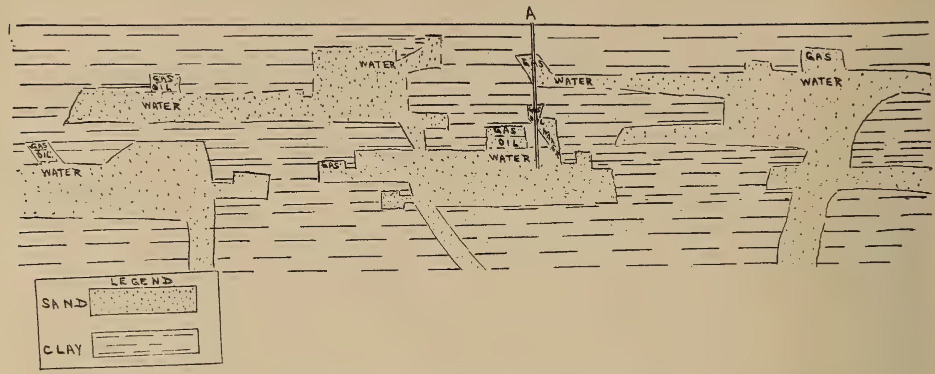


FIG. 4.—OIL IN SMALL POCKETS OF POROUS ROCK

Well *A* found only in the upper pocket, but came upon gas and oil in the pocket below. The oil is buoyed up by the ground water, and in its upward movement finds lodgement in these pockets.

sand were laid down along an ancient shore-line. Therefore, by knowing the location of this shore-line these old-time sandbars may be easily found. The oil pools in this field have their greatest length in a north and south direction, as must be the case with sand deposits along this shore that existed ages before man appeared. But the shore-line cannot be accurately located, as it is buried now under hundreds of feet of rock. This theory shows more distinctly how mysteriously hidden is the oil. However, when a lens is once located by drilling, if the strata is inclined the gas will occur at the highest point in the porous sand-lens next below the oil, and under that the water.

The Midcontinent field, just described, is the chief example of this type of oil accumulation. Another field is that of California, in which this mode of deposit is important.

Oil collects in small, isolated beds of porous rocks surrounded by non-porous rocks in nearly all of the other fields, irrespective of what the general structure of the region may be. Only by drilling can one be sure that oil-sand of value lies below (see Fig. 2. Oil acumulates near well C).

### OIL IN SMALL POCKETS OF POROUS ROCK.

In the Gulf field of Texas and Louisiana principally oil accumulates in small pockets or traps. These traps are composed of porous rock, the surrounding strata being shale or clay, which is non-porous (see Fig. 4). The oil is buoyed up by the ground water, and in its upward

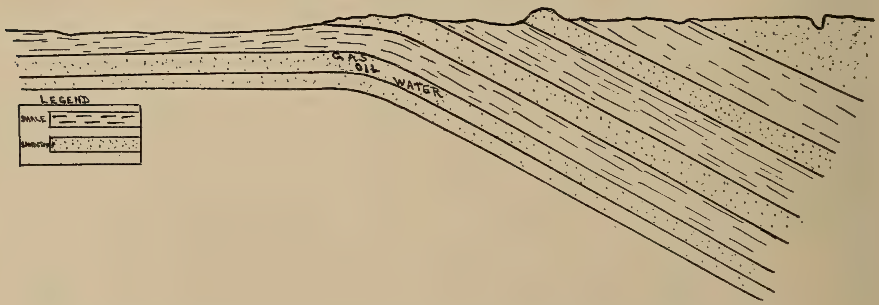


FIG. 5.—OIL IN ROCK WHICH SLANTS IN ONLY ONE DIRECTION (MONOCLINE)

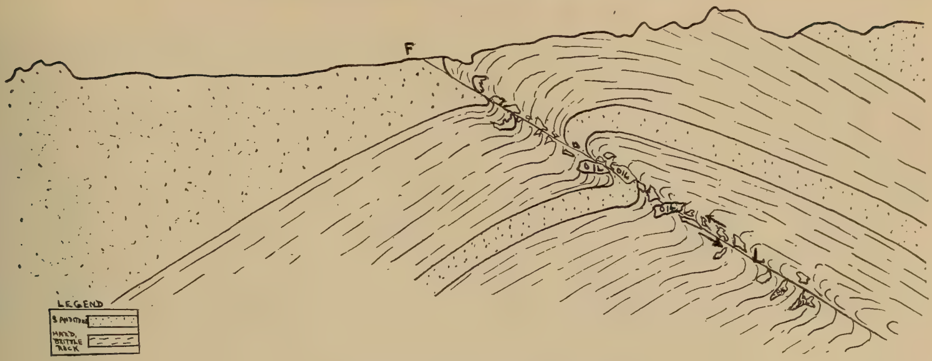


FIG. 6.—OIL ASSOCIATED WITH FAULTS

The rock was folded, broke, and that to the right slid upward along the line *F-L*. The rock adjacent to *F-L* was broken, and oil, rising up *F-L*, was caught in open spaces between the crushed rocks.

movement finds lodgement in these pockets, where it comes to rest.

It readily can be seen that it is impossible to ascertain the location of these pockets containing the oil, save by actual drilling. Where one well might strike oil, another only a few yards away would stand a fair chance of missing the oil-rock entirely, and even if porous rock were struck it would not necessarily contain oil.

### PECULIAR MOUND STRUCTURE

A striking peculiarity of the Gulf field are the low mounds, of which the celebrated Spindletop is a good example. This mound is but 10 feet above the adjacent prairie, and, in area, little more than 200 acres. The structure of the strata in these mounds is probably that of a lens of dolomitic limestone, concave below and convex above, the sides thinning out and gradually changing into the ordinary material of the Coastal plain deposits.

### OIL IN ROCKS WHICH SLANT IN ONLY ONE DIRECTION

Oil may occur in monoclines—that is, in strata which is inclined all in the same direction; hence the name (see Fig. 5). In this case the accumulation of oil would be similar to that of the minor folds on the sides of the large rock wave, already described under the anticlinal (rock wave) theory. The oil would rise in the porous rocks till it was stopped at the top of the incline by the non-porous rock above. Petroleum occurs in this way in California and Colorado.

### OIL ASSOCIATED WITH FAULTS

When the rocks composing the earth slip on one another, as a person slips playing-cards past each other, such slippings are called faults.

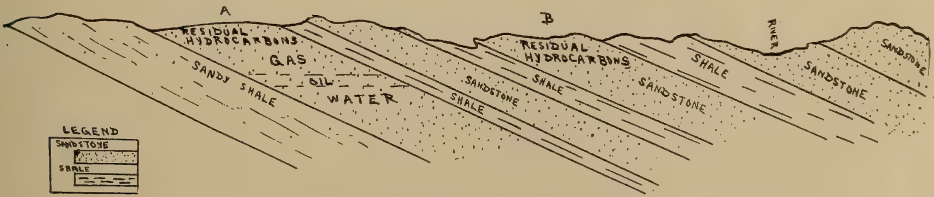


FIG. 7.—OIL IN ROCK HAVING NO ORDINARY ROCK ABOVE TO KEEP IT FROM ESCAPING

The oil is sealed in by residual material left by the previous evaporation of petroleum. At *A* the residual hydrocarbons filled the pores of the sandstone before all the gas and oil had evaporated. At *B* all the gas and oil evaporated before the pore spaces were filled.

The rock on either side of the plane along which the displacement occurred will be crushed and twisted. When the rocks are hard and brittle and not easily moulded into new shapes, open spaces will be left between the broken fragments. Into these spaces oil may rise and accumulate (see Fig. 6).

Oil deposits of this nature are found in California.

### OIL IN ROCKS HAVING NO ORDINARY ROCK ABOVE TO HOLD IT FROM ESCAPING

In California oil has collected in quantity where there is no impervious capping above the oil-sand. The sand outcrops (appears) on the surface, but the petroleum has been prevented from escaping by the heavy residual hydrocarbons which were left when, at the first period of formation of the oil it rose to the surface, the lighter, more volatile compounds in the petroleum being evaporated and escaping into the air. This heavy residual material left thus seals the outcropping porous sands (see Fig. 7).

### THE UNCERTAINTY OF SUCCESS

It is thus clear that an investment in an oil property which has not already numerous producing wells scattered over the entire area is an extremely hazardous venture. Because one well produces is no sign that the property is valuable, save for the oil that one particular well may yield. Or if a neighbouring company has wells whose output is large, it does not guarantee that an undeveloped property near by, which is being promoted by a company selling stock in glowing terms, with many promises of enormous dividends, is worth anything as oil land.

The reasons for this uncertainty have already been gone over in this article, but let us cast a hasty glance over some of the most important factors for the elusiveness of petroleum deposits.

To begin with, oil may not have been formed in the region, and, if it did form, it may be diffused through the rocks and not gathered in paying quantities. If it did gather in porous rock in volume, there may have been no impervious covering, and the petroleum would have escaped to the surface and been lost by evaporation. When the structure of the rock is that of waves, the porous rock may not be continuous over very large areas, but occur only in small, isolated patches having no relation to one another. Some of these patches may contain oil, others may not. Only drilling will solve the question.

Lenses and patches of porous rock, no matter what the general structure of the region, may occur anywhere. There is no sure guide to their location, and they are usually of rather limited extent.

Where oil is in small pockets the pockets cannot be located from the surface of the ground, and they will not all contain oil.

Even when the mounds occur as indication of oil, as in Texas, oil is not always underneath, and the area of oil-producing rock is small, with no certainty of surrounding duplications.

When an oil-sand is discovered having asphalt cemented into it, the petroleum already may have lost by evaporation (Fig. 7, B).

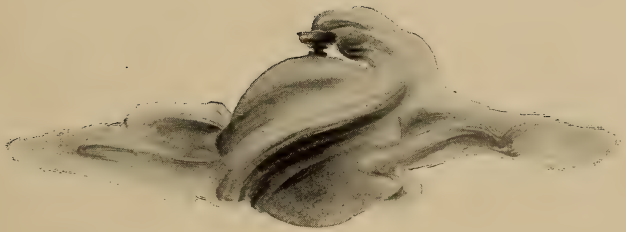
And so it goes with every known form of petroleum deposit—waves, lenses, faults, monoclines, etc.; they never can be located accurately and known to contain oil save by drilling. To make matters worse, after striking oil the sand will not always continue to produce petroleum for a long time. Some wells at the previously-mentioned Hamilton Switch oil-boom yielded oil for only a few weeks.

Even the best wells some time will cease to produce, so the investor must always keep in mind that, besides interest on his money, he must receive back his principal before that certain end to which every oil well is foredoomed, when the sands, having become exhausted of their liquid treasure, the well goes dry.

As a conservative investment, oil land will be reasonably safe which has been thoroughly proven by numerous producing wells scattered over the entire property, the wells having yielded for one or two years. To this must be added the other remedies against failure previously mentioned in this article, always remembering that the oil well some day will go dry, the sands having been drained entirely of their petroleum.

But, in order to make the greatest returns, unproven property is used, and the chances of failure are increased enormously.

Still many people have made fortunes easily and quickly in this gamble with Nature; many others, also, in all probability, will win.



# WASHING AND SORTING OF SMALL COAL

By N. T. Williams

THE question of washing small coal did not force itself on British coal owners as long as the supply of good and clean coal was maintained, but when they began to attack the inferior and dirtier seams they recognized the necessity of introducing some of the methods that have been commonly employed on the Continent for improving the product from such seams.

From the consumer's point of view clean small coal has great advantages.

The large and increasing demand for clean coke used in the manufacture of steel and iron has necessitated a more complete consideration of the methods of dealing with coal from bituminous mines. In smelting, when impure coke is used an increased charge of limestone is made necessary to eliminate the impurities, and there is also a danger of an excess of sulphur being present in the metal produced. Moreover, in handling the greater charges of coke and limestone in the process the cost of labour will be increased.

Again, in generating steam the use of impure coal gives rise to a great waste in combustion, owing to the excessive amount of ash forming clinker, which impedes the passage of air between the bars and the frequent removal of this clinker at a high temperature in the process of cleaning the fires: the fire-bars are rapidly destroyed through overheating, and the cost of the disposal of the ash is proportionately increased. Then in the manufacture of briquettes clean small coal is in great demand, and for clean nuts, etc., there is always a ready market. In addition, a great saving is effected in the handling and transport of the concentrated product.

Looking at the question from the producer's point of view: The laws that have been passed by the Government on mining have, for the most part, the effect of making profitable mining more difficult than it was formerly. Also, the insistent demand made by the workman on his employer for a greater share of the profits, together with the deeper, thinner and inferior seams that have now to be worked and the strenuous competition, has increased this difficulty. The short hours which the miner has now at his disposal has introduced more hurry in his work, and, in consequence, is not bestowing as much care as he should in filling the coal into the trams, and a great deal of unnecessary valueless material is loaded with the coal. This is hauled over long distances before it reaches the surface, and when it has reached the surface it has to be treated and finally disposed of, with consequent loss. A great amount of economy could be secured by inducing the workmen to fill the coal into the trams in as clean a state as the exigencies of the case will permit.

## COST OF WASHING

The cost of eliminating the impurities present in small coal by the process of washing will vary according to the size of the installation, type of machine used, physical nature of the coal, and quality and quantity of the impurities present.

Washing is more profitably carried out at a large colliery, or at a central washery, where the small coal from various collieries is assembled for treatment, than at a small colliery, because the cost of the larger plant for every ton of its washing capacity in a given time is less than that of a small plant, the staff is not increased proportionately, and the general expenses and labour bill are divided over a larger output. The cost of washing varies from one penny to sixpence per ton, according to the conditions previously stated. In South Wales the average cost of washing is about threepence per ton, exclusive of loss in washing, interest and redemption of capital outlay.

The increase in the value of the coal due to washing varies from fivepence to tenpence per ton.

The adoption of a washing installation will be warranted when the following conditions obtain:

(1) The small coal contains over 10 per cent. of free ash and little market for it in that state.

(2) The mineral leasehold is extensive and of long duration.

(3) Profits that can be made.

### SELECTION OF A WASHING PLANT

In selecting a washing plant the following points should be considered:

(1) Low first cost, consistent with economical handling of coal and refuse, and the production of clean coal, with little loss of coal in the refuse.

(2) Simple and reliable plant, which will not easily get out of order under the work it has to perform, and easy access to the different parts of the plant for inspection and repairs.

(3) Suitability to deal with the particular sizes of coal required by the market.

(4) Economical in the use of water—i. e., no water should be lost except what is absorbed in the coal.

Having considered the advantages derived from the preparation and use of clean coal, it will be convenient to describe, in a summary manner, the processes to which the dirty small coal is submitted in the mechanical process of washing.

The small coal which falls through the spaces of the fixed bar screen (these spaces vary in different districts in South Wales from 1 inch to 1¼ inches) and any additional quantity that may be manufactured through crushing are conveyed by shoots either into a railway truck to be transported to the washery or direct into the elevator pit. It is then raised by the elevator and delivered into shoots onto the screens. In the screens the coal will be classified into different sizes, each size dropping into a shoot and carried away in a stream of water into its washing trough or hutch. In the washers the coal is separated from its impurities and discharged over the sills into shoots and conveyed in streams of water to draining screens. At the draining screens the coal may be subjected to a spray of clean water, which washes away any particles of dirt which may be adhering to the coal. From here it is discharged into elevator pits and conveyed in perforated buckets into storage hoppers. The hoppers are provided with sliding doors, through which the coal is discharged into wagons.

The fine coal, after it has been separated from its associated dirt in the washers, is carried in streams of water into settling tanks, whence the coal is elevated in perforated buckets into hoppers and loaded into wagons.

The dirt discharged from all the washers may be carried by screw conveyors to elevator pits, whence it is raised in perforated buckets into hoppers to be discharged into wagons and taken to the refuse heap.

The dirty water from the draining screens, settling tanks, draining hoppers, etc., is conveyed to the spitzkasten. Here the fine coal previously held in suspension will be deposited and conveyed into the fine coal hoppers when sufficiently pure;

but, if the percentage of impurities present is high, the coal will be conveyed into the fine coal washers. The water, having been clarified in the spitzkasten, is conducted along launders back to the clean reservoir, from which it is circulated by a pump through the washery.

The clean coal from the nut washers, if intended for coking purposes, will be delivered to a disintegrator and pulverized into fine coal. In this state it is conveyed by elevator to the fine-coal hoppers.

It will be impossible within the prescribed limits of this paper to deal with all the types of machines used in washing coal. Under the circumstances, the writer will consider a few of the washing machines and the principal appliances used in washing installations, and they will be treated under the following heads—namely, Crushers, Conveyors, Screens, Spitzkasten, Dust Extractor, Washing Jigs, Trough Washers, Bumping Tables and Drying Washed Coal.

### CRUSHERS

In South Wales the average quantity of small coal that passes between the bars of the screen into the "billy box" amounts to about 25 per cent. of the coal tipped on the screen, the oversize passing on to other screens, where a further classification takes place. The undersize formed by the latter may be reduced in a crusher to a size according to requirements and made to join that which passed into the "billy box," therefore making a larger quantity to be dealt with in the washing machines.

Apart from this, the utility of crushing coal intended for coking purposes before washing into sizes not exceeding 1 inch cube will be easily recognized. The shale and iron pyrites that may be intergrown with the coal are split off, and subsequent washing will separate the impurities sufficiently to afford a good coke.

In most washing installations coal intended for coking purposes is also crushed after washing to a state of coarse powder—i. e., to a size about 1-16-inch cube. The uniform size thus produced will form a hard, dense and uniform quality of coke, free from fissures.

Crushers of the roller class are well adapted and extensively used for breaking coarse lumps of coal to smaller sizes, the crushing to be followed by screening and washing. When it is desired to break the coal to a certain size without reducing much to a smaller size, a series of rolls should be used, breaking first coarse, then finer, with screens between. This is a better plan than attempting to crush through one pair of rolls, because less fine coal is produced when crushing is done in stages.

Roller crushers are made from 15 inches to 30 inches diameter, and varying in length from 20 inches to 36 inches and fluted horizontally. The size, depth and pitch of the flutes are designed to break the coal to a required size. The capacity of rolls varies with the diameter, length, tangential speed and size of the lumps which enter and leave the crusher. Thus a pair of rolls 19 inches diameter by 24 inches and a tangential speed of 150 feet per minute will reduce lumps 2½ inches to 1 inch diameter at the rate of 40 tons per hour. When the coal is very hard, or if clayey material is present with the coal, it is preferable to use tooth rolls. In such rolls the teeth, which are diamond-pointed, are generally cast with the rolls. Sometimes they are made of steel and fitted into conical sockets made in the rolls, the distance between the points of the teeth of one roll and the other being dependent on the size that leaves the rolls. One of the rolls is in a fixed bearing, the other being adjustable and connected with rods and held in position by steel springs threaded on the rods, having a resistance sufficient to overcome the force necessary to

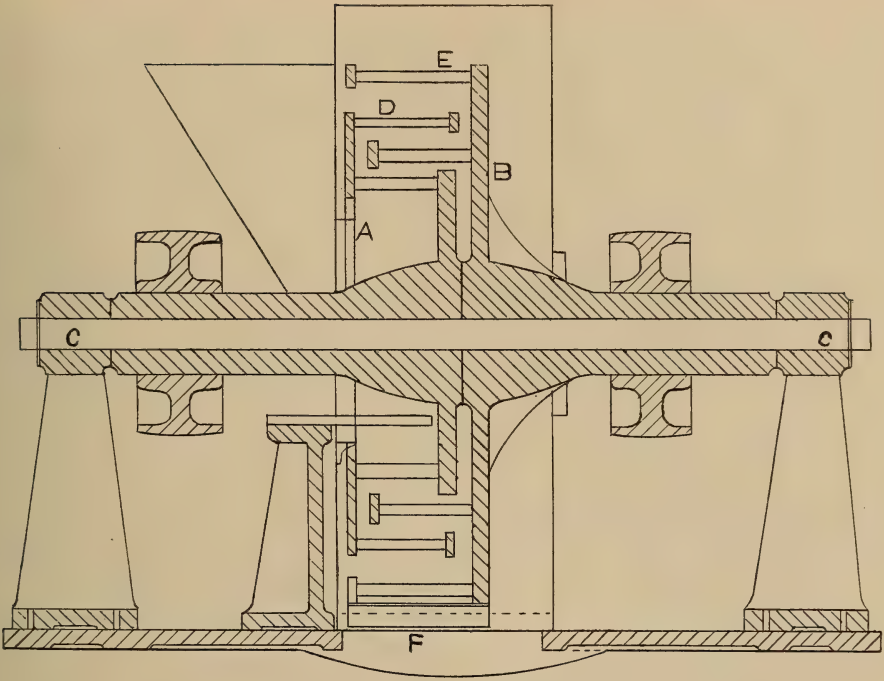


FIG. 1.—CARR'S DISINTEGRATOR

crush the hardest coal, but allowing pieces of iron, such as miners' wedges, couplings, or any other hard material, to pass through without breaking the rolls. The bearings of a well-made crusher are enclosed for protection from rust and provided with a thorough lubricating device, thus reducing the amount of power consumed to a minimum.

Like the fluted rolls, they are generally driven by belt and spur gearing fixed to each end of the shafts of the rolls. When the gear is fixed at one end of the shafts only, the shafts are subjected to unnecessary torsional strains.

For crushing the small lumps of coal which have passed through the washers to a uniform size, about 1-16-inch cube for coking or briquette making, the Carr's or Devil disintegrator is commonly used.

### CARR'S DISINTEGRATOR

Carr's disintegrator, Fig. 1, consists of two iron discs, *A* and *B*, supported on a shaft carried in end bearings *C C*. The discs are set at a fixed distance apart, and are provided with a series of concentric bars, *D, E,* the row of bars on one disc alternating with those on the other. The discs are provided with two driving pulleys, and are revolved in opposite directions by means of open and cross belts. Sometimes the pulleys are brought to the same side by making one shaft hollow. This arrangement is adopted by Messrs. Campbell, Bennie & Co. The coal to be broken enters the machine through an aperture in the side, and as it falls between the bars, which revolve at a high speed in opposite directions, the lumps are struck first in one direction, then in the opposite direction, this action continuing until the communited particles enter the circumferential space *F* of the iron casing, whence it escapes by an opening to a shoot in the bottom.

### DEVIL DISINTEGRATOR

The Devil disintegrator consists of two steel rings *A* and *B*, each furnished with rows of teeth of different sizes and arranged in concentric circles and interlocking, as shown in Fig. 2. One of the rings *A* is fixed and secured to the steel casing *C;* the other ring is secured to a disc *D,* which is keyed to a revolving shaft supported in long journals. The coal enters the machine at the centre and is ground between the teeth to the desired size by adjusting the thrust block and spiral spring at the ends of the shaft. Scrapers are attached to the disc, by means of which the crushed coal is scooped out at the bottom of the casing into a shoot. In this machine the coal is ground to a regular, uniform size, thus giving a better result than can be expected from a machine of the Carr disintegrator type.

## CONVEYORS

The conveyance of large quantities of material from one part of a washing establishment to another must be carried on with simplicity and economy. This is generally effected by means of elevators, shoots, screw and various other forms of conveyors.

*Elevators.*—For raising coal from a lower to a higher level an elevator is an indispensable accessory to a washing establishment, and is in general use for raising unwashed small coal from the fixed-bar screens and crushers to classifying screens and afterwards to convey in perforated buckets the different sizes of washed coal and shale to storage bins or wagons.

An elevator consists of endless iron or steel chains of various forms and a series of iron buckets, rounded at the bottom, so as to prevent coal becoming wedged between them and the elevator pit. The buckets are secured to the chain at regular intervals and caused to move around polygonal drums or sprocket wheels. Generally the upper drum is driven by means of gearing or pulleys at a speed varying with requirements, from 10 to 25 revolutions per minute. When the upper drum is driven it requires less tension on the chain to prevent slipping than if the lower is driven, because of the weight of the chain and the load it carries. Either the upper or lower pillow-blocks of the drums should be pro-

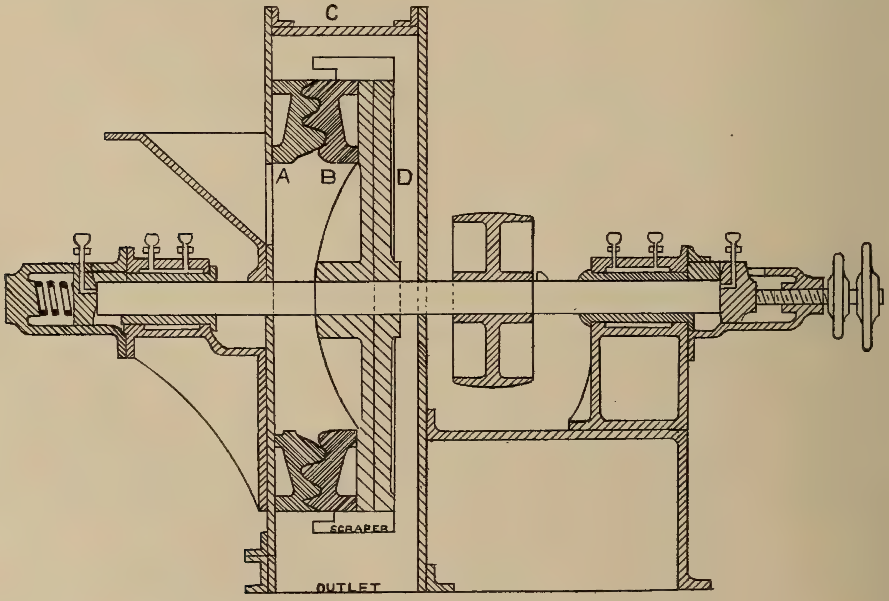


FIG. 2.—THE DEVIL DISINTEGRATOR USED FOR THE GRINDING OF COAL

vided with screws for adjusting the distance between the drums. By means of this device the chains can be easily fixed, and any slack can be taken up when they become worn. The upper pillow-blocks should be the movable ones; then the distance between the edge of the buckets and the bottom of the elevator pit is not altered. Should the screws be attached to the lower pillow-blocks, provision should be made for adjusting the base plates of the elevator pit, so that the buckets will always pass close to the bottom of the pit. The elevator frame is constructed either of wood or lattice steel work, having angle-iron guides fixed on either side, on which the chains are guided and supported. To insure a perfect discharge at the elevator head into a shoot, the framing is fixed at an angle of 20 to 30 degrees to the vertical. When the elevator is vertical, a special mechanism must be fixed at the upper drum in order to secure a proper discharge into the shoot; otherwise, the coal from the top bucket will be discharged on the back of the preceding bucket and down again to the elevator pit. A common form of elevator chain consists of single and double links alternately placed on edge and united by bolts or rivets. Each bucket is secured to the chains on either side by bolts, as shown in Fig. 3. Another plan is to bolt each bucket to two straps hinged from a pair of rods reaching across from one chain to the other, the rods fitting accurately into the holes in the ends of the links.

An excellent type of chain is made by the Primus Patents Company. The chain is composed of single and double drop-forged links, which are united by double-headed pins. To facilitate fixing and removal, each link is provided with an enlargement in the middle, as shown in Figs. 4 and 4a.

SHOOTS

Shoots are necessary adjuncts in conveying coal and shale for short distances in a washery. When the material is carried in a stream of water the angle of inclination need not be more than about 6 degrees, while for dry coal the angle of inclination has to be about 5 degrees more than the angle of repose of the material, this angle being 30 degrees for coal size about 1 inch cube. Shoots are constructed of sheet steel and of plank lined with steel.

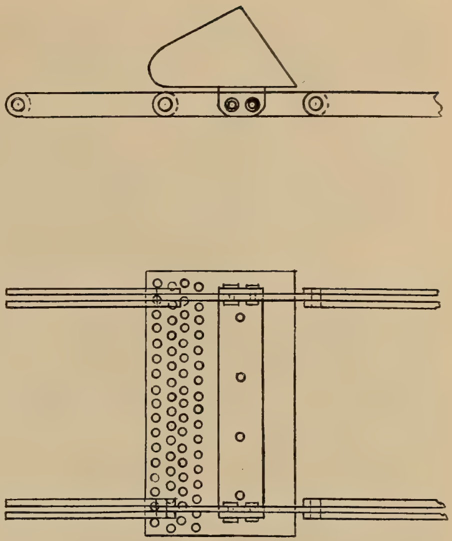


FIG. 3.—DIAGRAM OF BOLTS USED TO SECURE THE BUCKETS TO BOTH SIDES OF THE CHAIN IN THE COAL ELEVATOR

SCREW CONVEYORS

A screw conveyor is largely used for conveying dry or wet coal and shale in a horizontal or slightly inclined direction from one end of the screw to the other. It consists of a spiral, supported at intervals in journals, and revolves in a semi-circular trough. The quantity of material that such a conveyor can deal with in a given time depends on the condition and size of the material, revolutions, and diameter and pitch of the screw.

SCREENS

The raw coal delivered by the elevator is conveyed by means of shoots to screens, where it is graded for subsequent sorting in the washers.

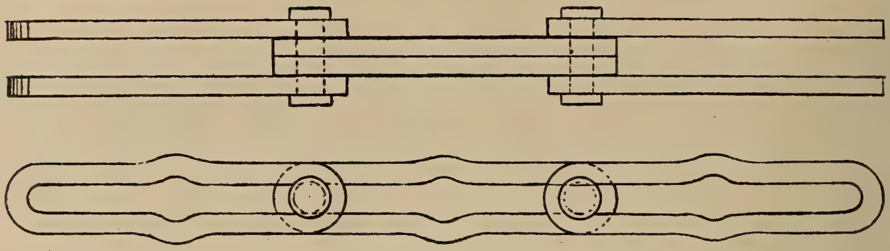


FIG. 4.—PRIMUS CHAINS FOR COAL CONVEYORS

Revolving screens or trommels are extensively used for this purpose. A trommel consists of one or more shells, either cylindrical or conical in shape. The screening surface is composed of perforated steel plates or wire gauze, the latter being used for the finer sizes of coal. A screen composed of one shell and cylindrical in form generally has its axis slightly inclined, so that the coal can travel from the higher towards the lower end. When the axis is horizontal, it is necessary to fix inside the periphery a spiral plate a few inches deep. By this means the coal is caused to travel forward as the screen revolves. If the shell is conical, the axis is horizontal, and the coal travels from the smaller towards the bigger end. The screening surface for either form may be kept in its place by circular straps and bolts, and may be supported on

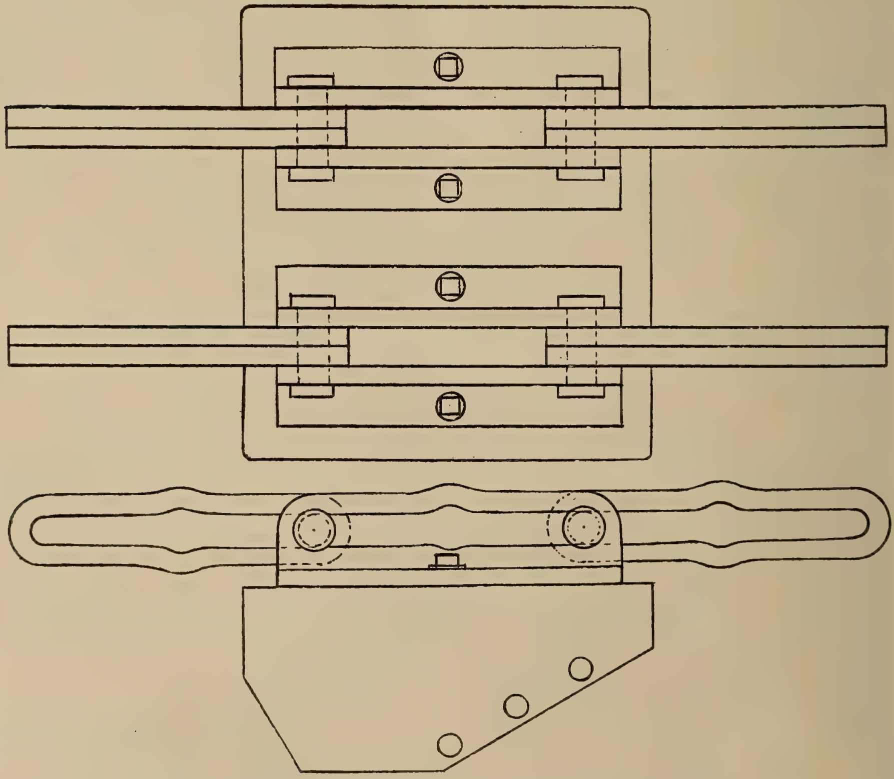


FIG. 4A.—COAL CONVEYOR USING PRIMUS CHAINS

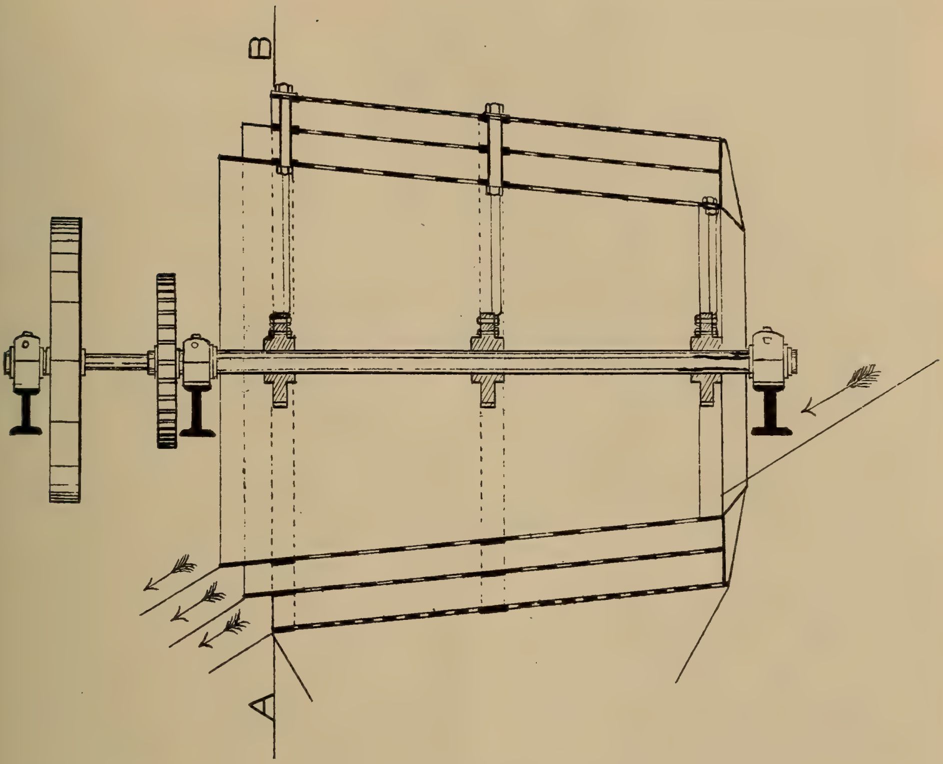


FIG. 5.—A CONICAL TROMMEL COMPOSED OF THREE SCREENS

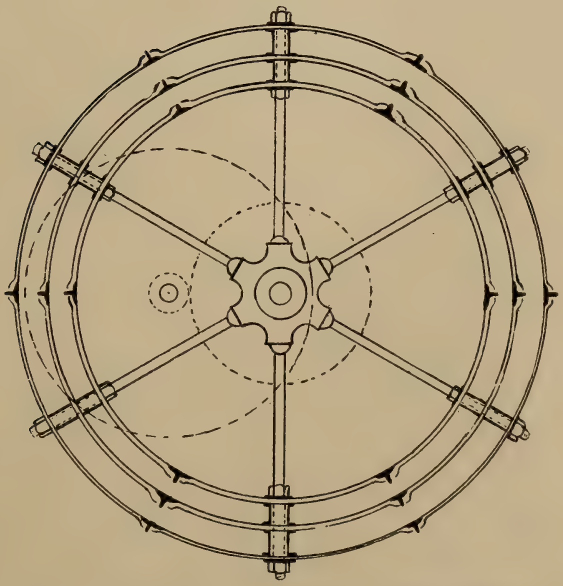


FIG. 5A.—SECTION THROUGH CONICAL TROMMEL WITH TRIPLE SCREENS ON LINE A-B

friction rollers, those on one side being rotated by bevel gearing; or the shell may be secured from a central shaft by means of "spider arms," in the same manner as a trommel composed of a number of concentric shells, the shaft being supported in journals at each end and caused to rotate by means of a pulley or spur gearing keyed on one of its ends.

Trommels consisting of one shell only are not much used in classifying coal for washing purposes, because they have to be very long to turn out a number of sizes of coal, and, unless of very large diameter, they are not suitable for accurate sizing of the smaller sizes of coal. Moreover, the finest screen must necessarily be placed nearest the end at which the coal enters, where it will be subjected to serious wear and tear. The only advantages that can be claimed for this type are cheapness in first cost and easy access for repairs.

Trommels consisting of a series of concentric shells, either cylindrical or conical in shape, are more in favour than the above type. A conical trommel composed of three screens is shown in Fig. 5. It is mounted on a central shaft, which is supported at both ends and driven by spur gearing and belt. The screening surface of each shell is made up in sections and united to each other by angle iron and bolts. The shells are kept at an annular distance apart of 5 to 9 inches by spider arms threaded with distance-pieces between each shell. One drawback of a screen of this form is that when one of the inner screens needs replacing the whole screening surfaces must be taken off. The trommel may be used for dry or wet screening. When the coal is dry the screen may be enclosed in a casing, to prevent the dust from escaping into the building.

This kind of screen can be made of dimensions large enough to deal with an output of 80 tons per hour when necessary. The peripheral speed varies from 50 to 150 feet per minute. In screening the finer sizes of coal it is difficult to keep the screening surface from choking. Various methods have been adopted to overcome this difficulty. One arrangement is to cause many blows to be delivered during every revolution of the trommel on a hoop fixed around the screen about the middle of its length, thus jarring the trommel and dislodging the fine coal which fills the meshes. Another arrangement is to have two strong collars at a certain distance apart on two opposite arms of the "spiders." On each arm between the collars a heavy sliding weight is placed, which falls twice during every revolution of the trommel, striking the collars and causing a jar each time. A method employed in wet screening is to place a small pipe over the top and parallel to the length of the screen; a section of the pipe facing the screen is perforated. Jets of water issuing through the perforations at a high pressure play on the outside of the meshes and clear them of any fine coal.

### VIBROMETER

A screen very suitable for sizing dry small coal for a washing establishment is the Vibrometer screen, made by Messrs. Hardy Patent Pick Company. The vibrometer consists of an incline screening surface secured in a frame freely suspended by four wire ropes held in clamps on the sides of the screen and the framing above, as shown in Fig. 6. Over and above the screening surface is a steel box, which contains an unbalanced weight *W*, which can be fixed in any position on an arm keyed to the spindle *S*. The spindle works in bearings fixed in the box, and has its upper end united to a vertical jointed rod *J*. The upper end of the rod is united through a similar joint to a spindle *O*, which carries a pulley *P*. When the pulley is rotated the end of the spindle in the foot bearing will describe a circle in a horizontal plane, and the unbalanced weight causes the

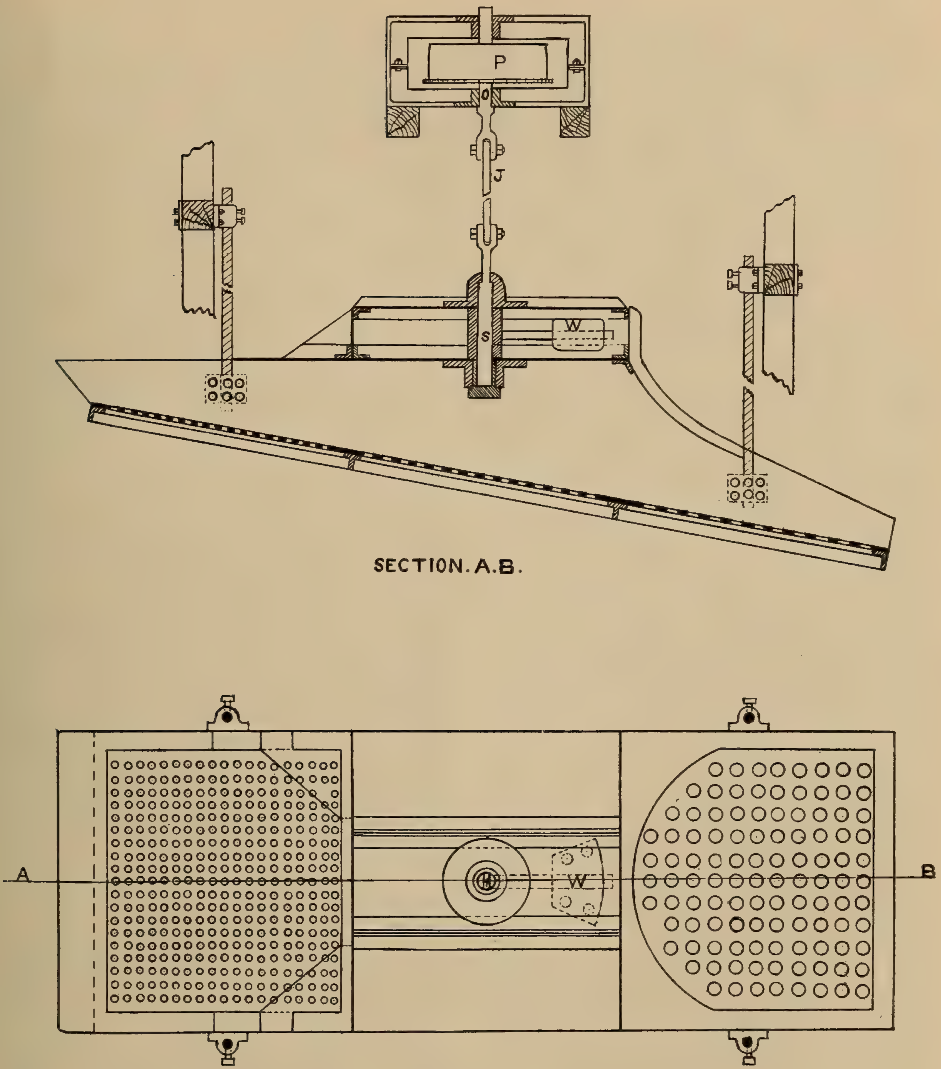


FIG. 6.—VIBROMETER SCREEN USED FOR SIZING SMALL COAL FOR WASHING. MADE BY MESSRS. HARDY PATENT PICK COMPANY

screen to have a gyratory movement, the radius of gyration being dependent on the velocity of rotation of the pulley and the position and magnitude of the unbalanced weight. Owing to the movement and the inclined surface of the screen, particles placed on it will descend, describing on the way a series of ellipses over a large area of the screen, giving a very satisfactory result in screening. Due to the tendency to automatic balancing, very little power is required to drive the screen, and no vibration is produced. It can be driven at a high speed, the pulley making from 200 to 350 revolutions per minute. The width of the screen shown is 4 feet and length 11 feet.

Neither of the screens just described is suitable for separating sizes below ¼-inch mesh, because the screen becomes choked.

The Callow screen, as made by Messrs. Fraser & Chalmers, Ltd., can screen satisfactorily extremely fine sizes. The screen consists of an endless wire-woven belt, traveling slowly over two pulleys. The undersize passes through the screen into a hopper between the pulleys; the oversize remains on the top of the screen until it is removed, when it passes over the pulley.

### SPITZKASTEN

Coal below ¼-inch size that has passed through the screen can be classified into many sizes in a spitzkasten and the different sizes passed into the fine coal washers. The spitzkasten, Fig. 7, consists of a series of inverted pyramidal boxes having an aperture *A* at each apex, through which the classified material is drawn off by means of a valve gate. The boxes, from the point at which the material is fed to the discharge end, increase in length, width and depth. By this means a different class of product is found in each box, the coarser stuff being found in the first and smallest box, where the velocity of the water is greatest and capable of holding the finer particles in suspension. The last and largest box will contain the fine particles, as the velocity of the stream at this point is least. The sides of the box must slope not less than 50 degrees to the horizontal, in order that none of the material may be deposited on them.

### DUST EXTRACTOR

It is a decided improvement if the fine dust is extracted before the fine coal goes to the washery. The fine dust so removed may be added to the washed smudge, which would help to dry it. The dust cannot be added if it contains too high a percentage of impurities. In that case, it may be used as boiler-fuel at the colliery when the boilers are fitted with apparatus for utilizing coal in the form of dry powder. By extracting the dust, the amount of "schlamm" or slurry is reduced to a minimum, and the difficulty of obtaining clarified water for re-use in the washery is much reduced. Various methods have been adopted for eliminating the dust. The most successful and economical method hitherto is the employment of a fan, whereby the dust is removed by the induced draft as the coal falls onto the classifying screens. This system of dust extraction is adopted by Messrs. Hardy Patent Pick Company, the makers of the Elliot washer. A similar system is adopted at the Cardiff washery erected by Messrs. Meguin & Co.

### WASHING

Coal below about 2 inches diameter cube mixed with impurities cannot be cleaned economically and efficiently by hand picking; consequently, recourse has to be made to a mechanical process of washing for effecting the separation. This washing process is based upon the difference in the specific gravities of the coal and the various impurities mixed with it. The average specific gravities of these are: Coal, 1.25 to 1.50; bone coal—i. e., shale with coal adhering to it—1.45 to 1.80; shale, 2.3 to 2.50; coal or shale with pyrites, 3 to 3.50; pyrites, 3 to 5. When these minerals are subjected to the action of water the different particles will have different velocities, settling in accordance to their respective specific gravities, the heaviest first and the lightest last, provided the particles are approximately of the same size. The sizing of coal (previous to washing) is indispensable when due attention is given to obtain efficient results. Almost all washing machines are arranged on this plan, to treat the different sizes separately.

The principal types of modern appliances using water as a medium for sorting coal from impurities will now be considered. These are:

(1) Jigs (a). Jigs for nut washing, with sieve fixed and a movable piston for producing the necessary intermittent ascending current, or the

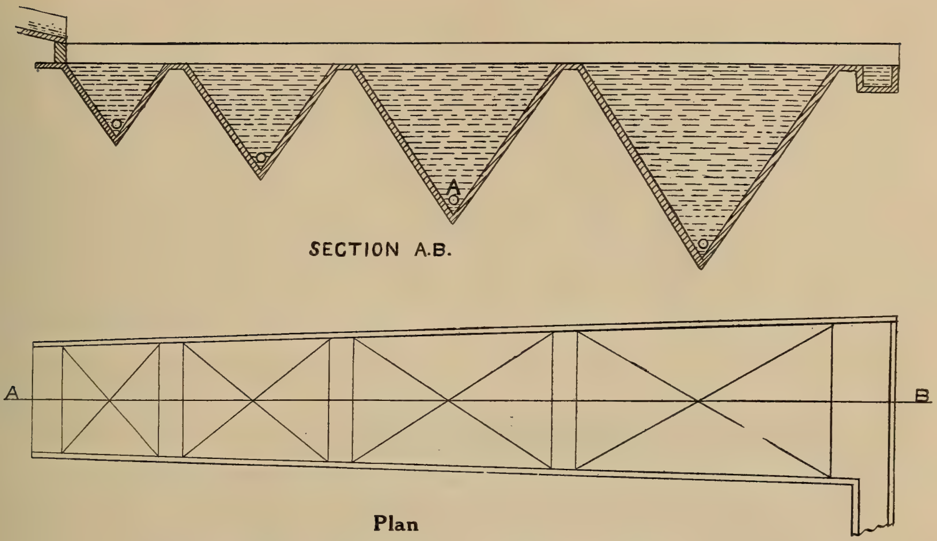


FIG. 7.—DRAWING OF A SPITZKASTEN USED TO CLASSIFY COAL BELOW THE ONE-QUARTER SIZE

sieve in the form of a box may be moved up and down in the water. (b) Jigs for fine coal washing—Felspar washers. In these washers the sieve may be fixed or movable, as in the case of the nut washers.

(2) Trough washers, of which the Elliot is an example.

(3) Bumping tables, of which the Craig washing table is an example.

### JIGS

A common form of jig for treating coal from ⅜-inch upwards, known as the nut coal washer, consists of a wooden, steel or cast-iron hutch. The upper portion is rectangular in plan and divided into two compartments by a short vertical partition about 18 inches in depth.

In the back compartment works a wooden or cast-iron piston, which is attached to one or two piston rods, according to its size. These, in turn, are attached to double disc eccentrics supported on a shaft above the hutch. By shifting one of the discs and tightening up the bolts that connect the discs, the throw can be varied as desired. For reducing the suction a crank and sliding-block in a slotted lever is sometimes used. This contrivance will give a quick down and slow upstroke to the piston. The piston when at mid-stroke is about level with the sieve.

The front compartment contains the sieve, dipping slightly from the feed shoot towards the discharge end. The sieve is composed of perforated plates secured to a frame and resting on iron or wooden grids. The front of the sieve compartment is cut down about a foot below the level of the other sides and provided with a shelf and discharge trap for the water, coal and shale to escape. The water enters the hutch through a pipe provided with a valve below the piston, to supply that which is displaced by the piston and minimize the action of suction. The bottom of the hutch is made concave or pyramidal and provided with a central opening for the discharge of fine particles falling through the sieve.

*Principle of Action of the Jig.*—After the hutch has been filled to overflowing the supply of water is continued, and the coal, carried in a stream of water, enters near the partition, as shown in Fig. 8. Every downstroke of the piston forces the water through the sieve with sufficient velocity to lift the coal and its

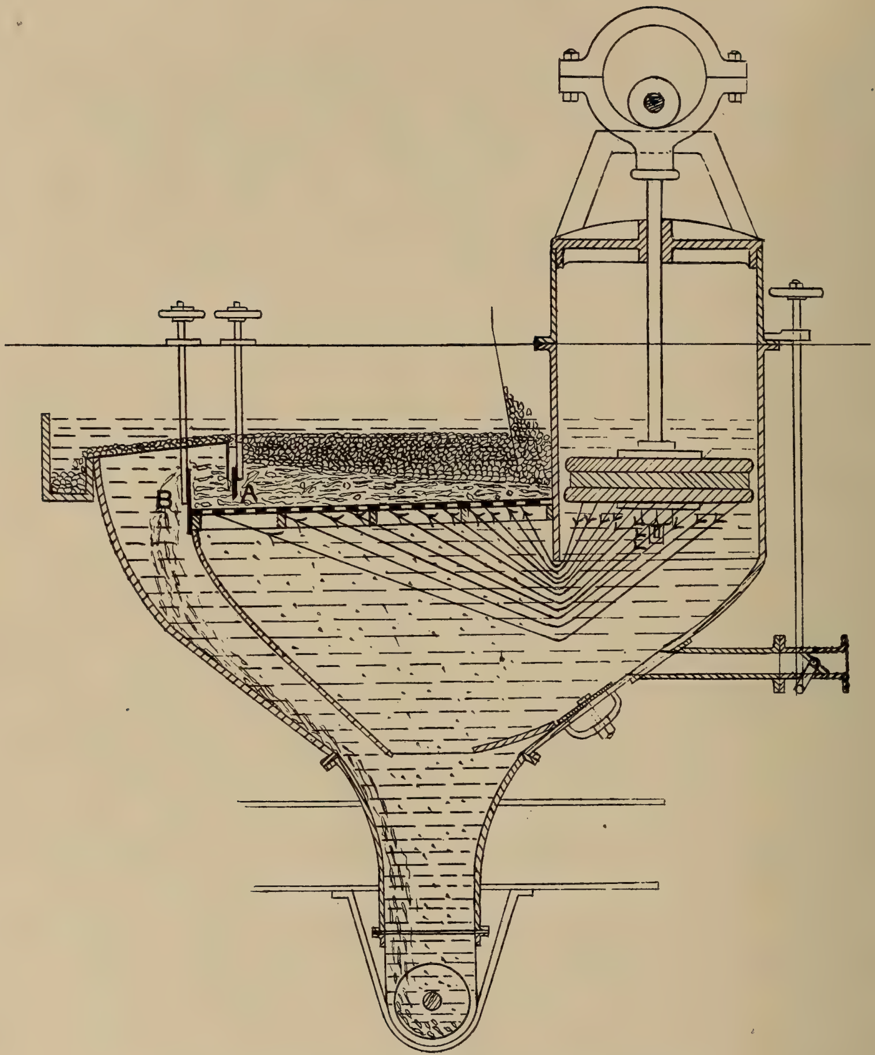


FIG. 8.—DRAWING SHOWING THE PRINCIPLE OF ACTION OF THE JIG

impurities a short distance from the surface of the sieve. A greater velocity will be communicated to the coal than to the impurities, and during the upstroke of the piston the reverse will take place: the heavier particles sink faster and lower than the lighter coal. This alternating movement of the piston being repeated many times during the time of travel of the minerals from rear to front, the minerals will be separated in horizontal layers, according to their specific gravities. The separated coal and shale will be discharged over their respective sills, from where they are removed by conveyors or some other contrivance. The force of the upward current is regulated to suit the sizes of coal treated. If the current is too strong it will derange the separation of the coal from the impurities; if too weak, it will fail to effect the separation of the coal from the impurities. Proper washing requires that the raw material should be fed evenly in thickness and rate of supply proportioned to the rate of discharge, and the action of the water to be uniform all over the under side of the sieve.

When the piston is placed at the rear of the hutch—which is generally the method adopted in the construction of nut washers, as shown in Fig. 8, which is a hutch similar to the Meguin type—the length of the sieve is limited to about 5 feet, and only a portion about the middle of the sieve is effective in producing accurate stratification of the minerals. This defect is further intensified by the greater depth of the charge at the front end, where the force of the water current is least, as indicated by the number of arrows. The force of the water current is greatest where the amount of the material is least. A partial remedy for this evil is to make the screen level. The minerals then form a uniform bed instead of an uneven one, as is the case on an incline sieve, and by placing the piston in a compartment parallel to the screen and of the same area as the latter. By this arrangement the screen is longer; consequently, the piston makes a greater number of strokes, while the coal travels over the screen, resulting in a more uniform separation of the coal and shale and obviating the necessity of rewashing when the minerals are nearly of the same specific gravity. The width of the screen compartment is, of course, limited to about 2 feet.

The most rational method of obtaining a uniform action of water through the mass of coal in a washer is either by (a) placing a plunger directly under the sieve, or (b) giving a vertical reciprocating motion to a perforated pan or sieve in the water.

(a) When the plunger or piston is placed under the sieve it can be made of any size and good results obtained provided the plunger is made of approximately the same dimensions as the sieve. The Diescher machine is constructed on this principle, and has been employed in the United States for many years with great success. Briefly, the machine consists of a buckled piston provided with small holes at the apex of each buckle, to allow to escape into the lower part of the hutch any fine particles that may pass through the sieve. Water enters between the plunger and the sieve. This arrange-

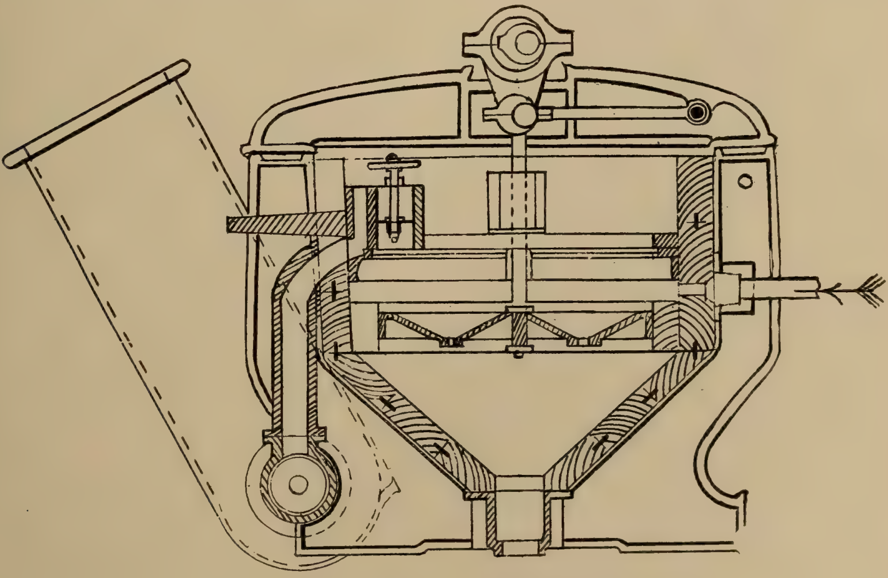


FIG. 9.—SECTIONAL ELEVATION OF THE DIESCHER MACHINE

ment obviates the necessity of valves in the plunger and the suction is reduced to a minimum. It occupies less space than the ordinary hutch, and a less quantity of water is set in motion for a given output than with the ordinary hutch. The length of stroke and the number of strokes which the plunger makes per minute depend on the state of the material operated upon. These will vary in the inverse ratio to the size of the coal treated. Fig. 9 shows a sectional elevation of the machine.

(b) The best-known machine using a reciprocating pan for agitating and separating the coal from the shale is the Stewart washer. A great number of these machines have been installed in the United States of America, and a modification of this machine, known as the Christ jig in the States, has been lately introduced into Great Britain, and is called the Primus Coal Washer. The Stewart jig consists essentially of a jig box *B,* Fig 10, with perforated bottom, freely suspended in a water tank *W* and worked up and down by a pair of adjustable eccentrics on shafts *S* and *T.* The coal, which enters at *E,* is jigged many times before it reaches the discharge *D.* As the box goes down, the water is forced through the perforated bottom with sufficient force to carry the coal forward to the discharge gate, whence it slides down the shoot into the tank *F,* from where it can be removed by an elevator. The heavier refuse passes through the adjustable gate *A* into the jig tank *W,* from where it is removed in the same manner as the coal. The water is pumped from the tank *F* to the supply tank *H.* During the upstroke of the jig box the water passes from the tank *H* through valve opening *V* into the tank *W,* filling the vacancy caused by the upstroke of the box and preventing suction. This form of jig is very sensitive and suitable for dealing with coal containing impurities approaching the specific gravity of the coal itself. Results have been accomplished by this machine which show a very low percentage of dirt in the washed coal and the percentage of coal in the refuse a negligible quantity.

### AUTOMATIC DISCHARGE

The design of a gate for automatic and continuous discharge of the products from a washing jig is a very important consideration in efficient washing. Several forms have been designed, all having the same object in view—the removal of the refuse at the rate at which it is produced. A common form satisfying the conditions is shown in Fig. 8. It consists of a trap or enclosure provided with two vertical sliding gates, one some distance in the sieve compartment, the other located where the refuse drops to a screw conveyor or elevator. The material in the enclosure is under the action of the current produced by the piston. The gate *A* is lowered a certain depth into the material until there is sufficient opening for the refuse to pass freely under it and enter the trap as fast as it is brought upon the sieve with the coal. With every upward movement of the water some of the refuse within the trap falls over the outer gate *B* into the screw conveyor. If the gate is opened too much, there is a danger for some of the coal to pass along with the shale. The gate *B* must be low enough to keep the shale from passing over the sill with the coal.

### FELSPAR WASHERS

The machines under this heading are of two kinds:

(a) Jigs with fixed sieves, the piston working in a compartment parallel to the sieve. This kind of jig forms the greater number of machines in use at present.

(b) Jigs with movable sieves.

Both types of machines use a bed of felspar on the sieve.

(a) Jig with fixed sieve. This type of machine is of similar con-

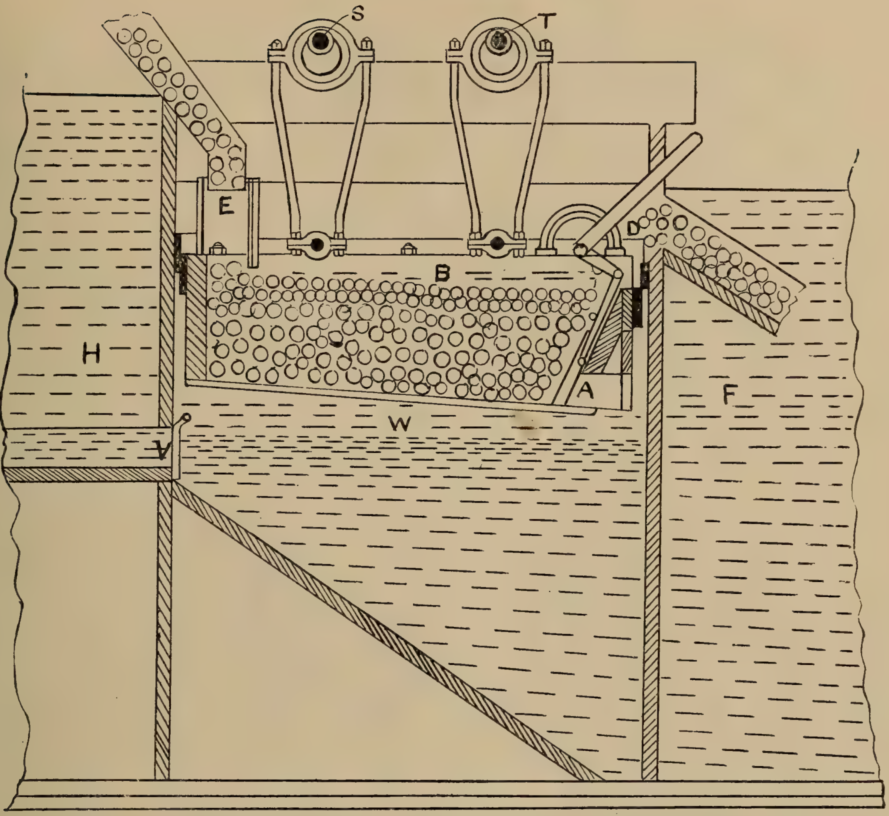
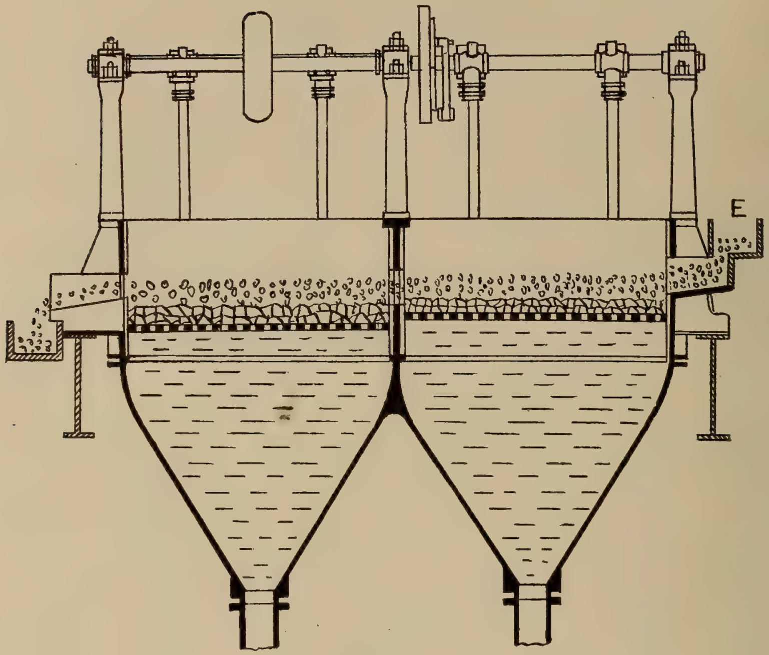


FIG. 10.—DRAWING OF JIG BOX USED ON THE STEWART MACHINE

struction to the nut coal washer. The hutch is divided longitudinally into two compartments by a short vertical partition. One compartment contains the sieve, the other the plungers. The hutch is also divided transversely into two compartments, each communicating with the other by an opening above the sieve (see Fig. 11). On the sieve a bed of felspar (*Sp. Gr.* 2.6) from 2 to 4 inches thick is placed. The pieces of felspar are prismatic in shape, the holes in the sieve being considerably smaller than the pieces of felspar, but larger than the size of the coal treated. The felspar has to be renewed when the corners become rounded. The dirty coal to be washed is conveyed in a stream of water and is introduced at one end *E* of the sieve and travels over the entire length of the felspar bed, the clean coal being finally discharged at the opposite end and thence conveyed by mechanical means to a bunker.

When the washer is filled with water to the level of the discharge sill and the plungers are working up and down with rapid, short strokes the water is forced through the sieve, lifting the felspar, coal and shale at each downstroke of the plungers, separating the materials into layers, according to their specific gravities. The impurities, being about the same specific gravity as the felspar, fall on the return downcurrent through the interstices in the felspar bed into the hutch below, to be removed continuously or intermittently. The coal being lighter, passes over the "bed" to the discharge, from where it can be conveyed by any mechanical means to



SECTION.A.B.

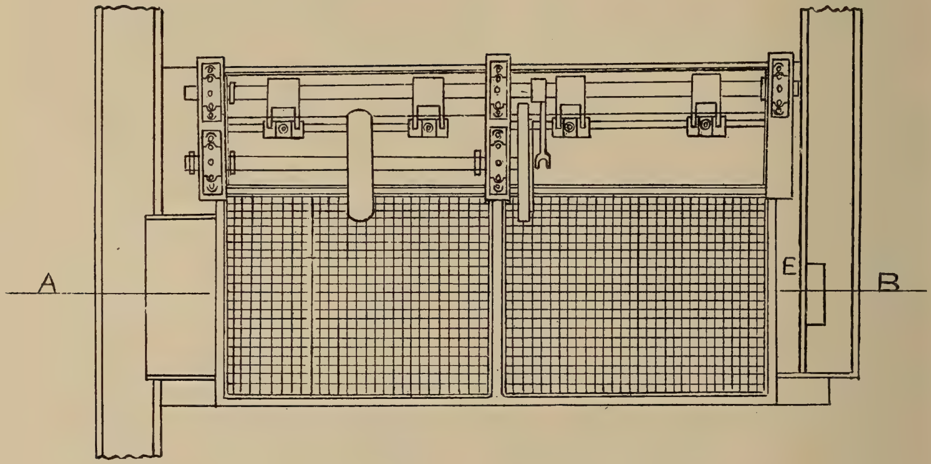


FIG. 11.—FELSPAR WASHER, SHOWING PLUNGERS AND SIEVE

the bunkers or other place of storage.

The function of the felspar bed is to act as sort of valve, opening to the ascending current of water and closing when the current descends, thus allowing the impurities to pass through, but not the coal. A felspar bed is applicable for sizes of coal up to ⅜-inch mesh. Above this size the mesh would have to be larger and the felspar coarser. On this account a considerable quantity of fine coal would pass through with the refuse. It is impossible to treat fine coal from ⅜-inch downwards without a bed of felspar or similar material, as the meshes of the sieve would become choked with the fine coal. A bed also allows a much coarser sieve being used. The speed of the plungers varies from 100 to 200 strokes per minute, and the length of stroke varies from 1¼ to ¼ inch, according to the coarseness of the coal to be washed, the high number of strokes and the short stroke adopted for the finer sizes of coal.

The speed of the nut washing plungers varies from 50 to 100 strokes per minute, and the length of stroke varies from 5 to 1½ inches, according to size of the coal treated.

(b) Jigs with movable sieves. The best-known of this kind is the Sheppard two-compartment felspar washer. The sieves are attached to two rods, which are secured at their upper ends to a rocking lever, as shown in Fig. 12. By this arrangement the sieves and their contents are balanced and the action of the water on the underside of the sieves is uniform. The water enters the hutch at the points *A A*. The shale, which falls into the hutch, is removed by screw conveyors *S S*. The plungers make one hundred and eighty ¼-inch strokes per minute on coal which has passed through a ⅜-inch mesh.

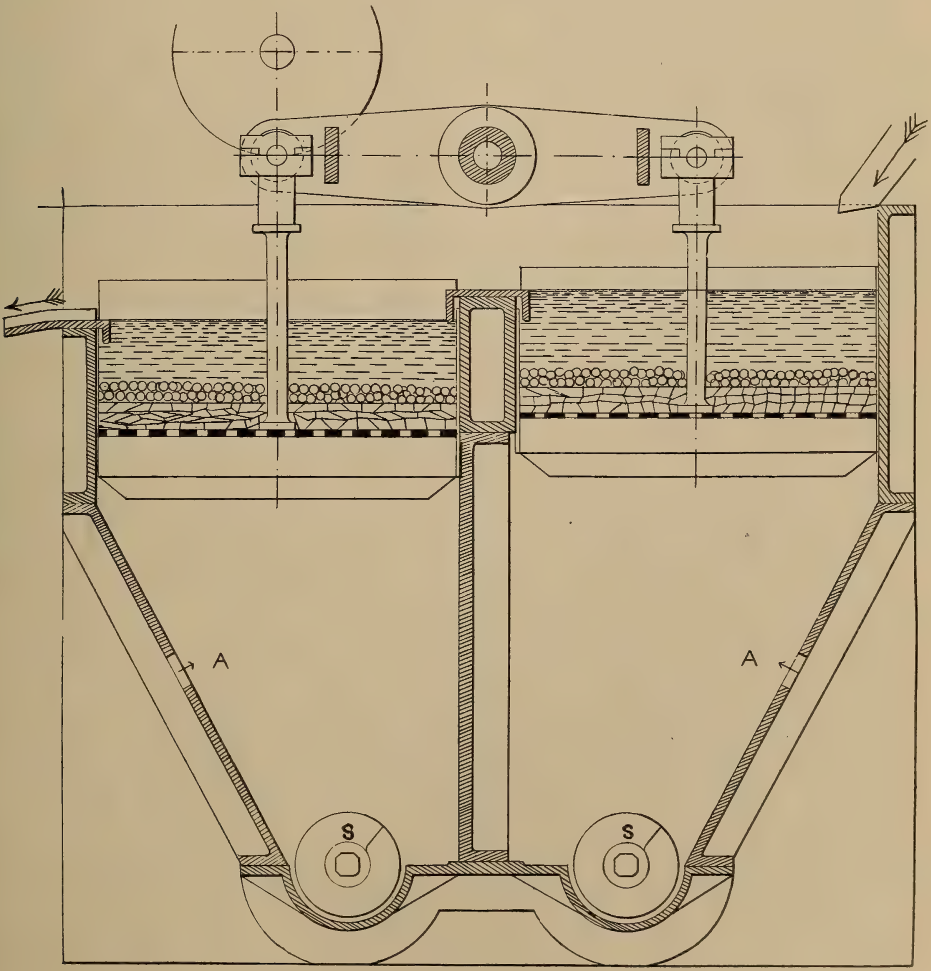


FIG. 12.—SHEPPARD TWO-COMPARTMENT FELSPAR WASHER WITH MOVABLE SIEVE

### TROUGH WASHERS

The Elliot trough washer is an improvement on the old trough washer, which retains all the advantages of simplicity and economy of the old system, without any of its drawbacks. It is automatic and continuous in its action, the coal and water being delivered at the lower end and the dirt at the upper end of the trough. The washer consists of a cast-iron or steel trough about 18 inches wide at the bottom and 30 inches wide at the top and 12 inches deep, and about 60 feet long, (see Fig. 13), set at an inclination of 1 in 12 for general purposes. For treating coal between 2 and 3 inches diameter a steeper inclination will give better results. At each end of the trough sprocket wheels are fixed, driving endless chains, to which concave and convex scrapers from 1½ to 3 inches deep are attached at distances of 2 to 5 feet apart (the smaller dimensions are applicable to the finer sizes of coal). The scrapers travel along the bottom of the trough to the upper end and then return over the trough, being carried on rollers *R* at regular intervals. The scrapers form movable dams, which carry the refuse to the upper end, whilst the washed coal is carried by the water over the dams to the lower end of the trough and discharged onto draining screens and into the boot of an elevator, to be raised into the coal bunkers. The coal from the classifying screens is delivered to each trough about the middle of its length. The water is admitted at the upper end of each trough. By this arrangement the clean water in the upper half of the trough serves to wash down any coal which may have been caught by the scrapers, so by the time the scrapers arrive at the upper end the refuse is practically free from coal. By adapting the quantity of water, the speed, number and height of the scrapers and the inclination of the trough, any class and size of coal, from 3 inches down to the finest grains, can be treated efficiently and economically with less power than is required for jigs having the same output.

The principal wearing parts are the scrapers, which are simple and inexpensive, and can be easily made at the colliery. The output per trough varies from 4 tons per hour for the smaller sizes up to 12 tons per hour for the larger sizes of coal. The wastage of water is confined to what is taken away in the washed coal.

### BUMPING TABLES

Bumping tables are not extensively used for washing coal. The Craig table has, however, attained much success in washing small coal which has been previously crushed to a size suitable for coking purposes. It has the advantage over jigger washers in requiring less machinery for treating and preparing coal intended for the conversion into coke.

The coal, after it has been crushed to a uniform size, is elevated into a "scrubber," which is a large cylindrical bunker provided with rotating arms. Here the coal is thoroughly mixed with water. From the "scrubber" the wet coal is delivered to many tables to be washed. The principle involved in the separation of coal from the dirt is the same as for all other washers—namely, the difference between the specific gravities of the coal and the impurities; but the method of operation depends on the motion and momentum of the table. The table consists of a Y-shaped tray mounted upon wheels running on inclined rails, as shown in Figs. 14 and 15. The forward motion of the table is caused by two-armed cams *C* working against a steel block fixed to the end of the table. A quick return motion is produced by a strong spring *S*, which brings the table against the buffer *B*. The cam shaft makes about 30 revolutions per minute, and the stroke of the table is about 6 inches. The inclination of the table can be altered by means of screws *M M*. The floor

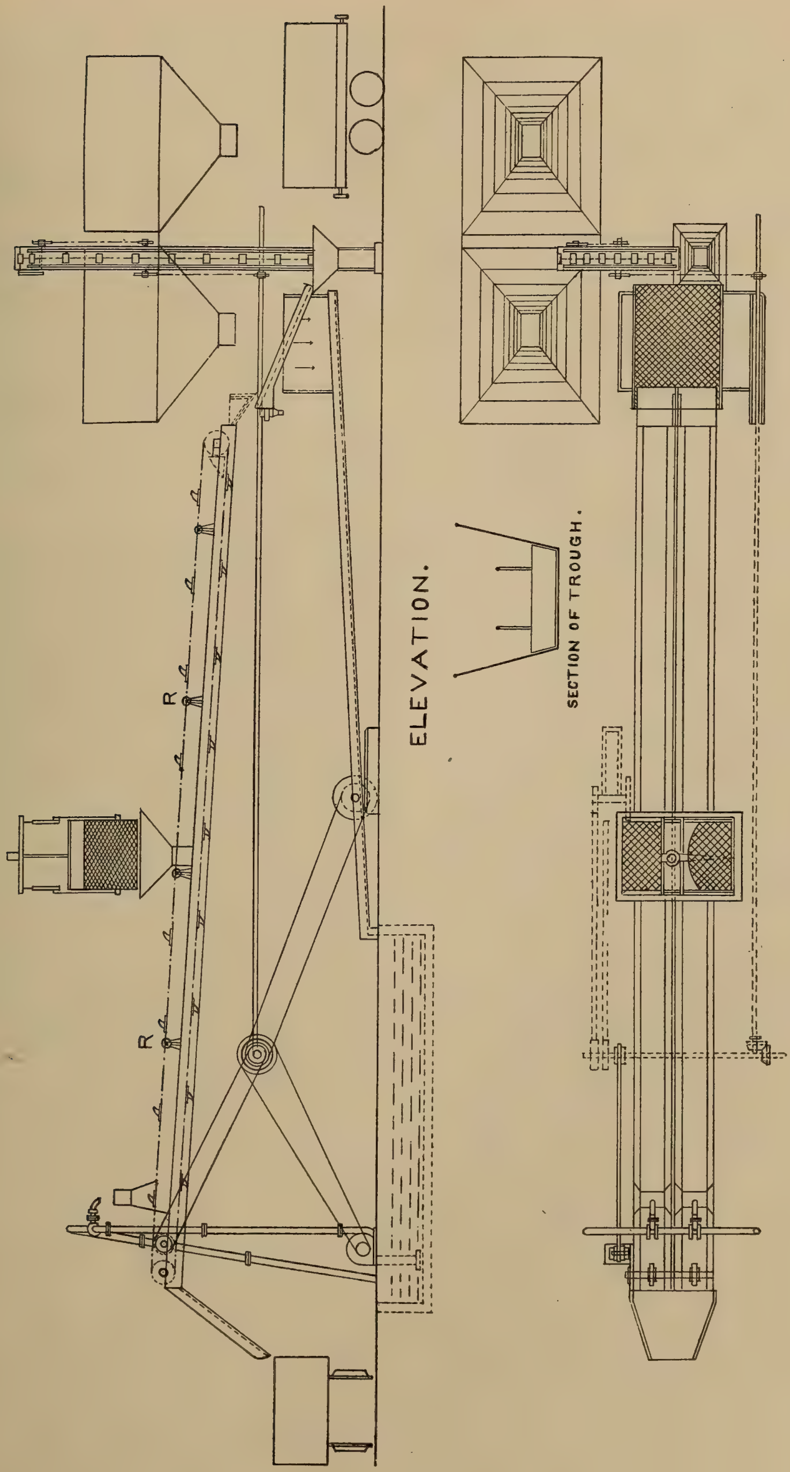


FIG. 13.—DIAGRAM OF THE ELLIOT TROUGH WASHER USED TO WASH COAL AND SEPARATE IT FROM DIRT

of the table consists of steel, so arranged to form riffles, over which the material moves. The coal from the "scrubbers" is fed onto a shoot attached to the table, which delivers it about the middle of the table. The coal is distributed evenly over the machine by means of "water-sprinklers" *W*. The water, flowing over the table, washes the lighter coal towards the discharge end *D* into a screw conveyor, whence it is conveyed into draining tanks. The heavier impurities settle to the bottom of the table and are caught by the riffles and finally discharged at the points *P P*. By the motion of the table the material is stirred up in the water, which brings about a very efficient separation of the coal and shale, and the momentum acquired during the return stroke of the table causes the heavier shale, when the table is suddenly stopped by striking against the buffer, to move towards the buffer and discharge at the outlets *P P*. At the outlets sprays of water act on the shale, which washes it away into shoots. The washer has a capacity of from 5 to 7 tons of washed coal per hour. One ton of coal requires about 200 gallons of water to wash it.

### DRYING WASHED COAL

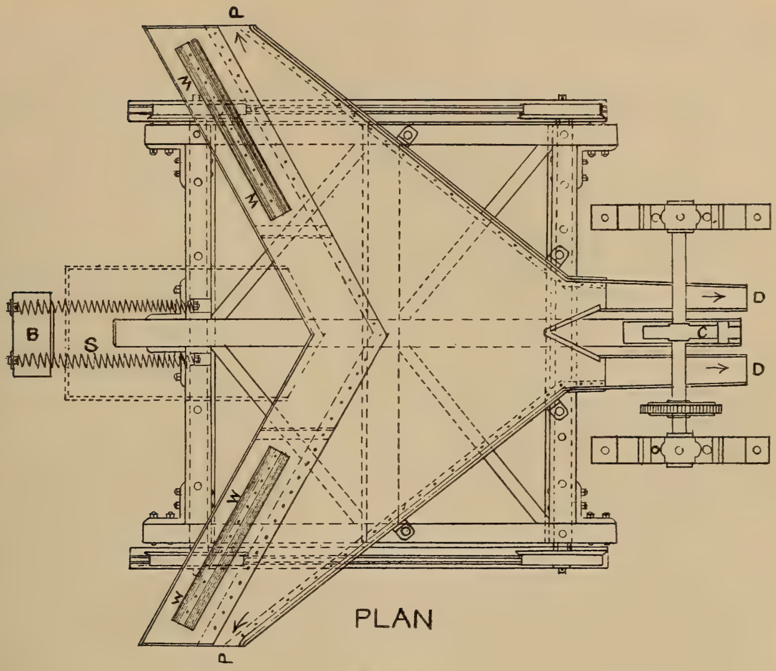
Washed coal intended for coking purposes must not contain more than 10 per cent. of moisture. Over 10 per cent. of moisture in the coal has a destructive effect on the brickwork lining, as well as lowering the temperature of the oven when the coal is introduced into the oven. Efficient drying of washed coal for coking or briquetting purposes is an important operation. The drying of nut coal is not so important or difficult. There are three methods in vogue for drying coal, and are known as follows: (1) Wet System. (2) Dry System. (3) Cylindrical Driers.

(1) In the Wet System the water carrying the washed coal runs into a series of tanks or bunkers in succession. The coal settles in the first until it fills it to the top, whereupon the water containing coal is diverted into the next bunker, and so on until the last bunker is filled. The fine coal in the bunkers is gradually drained of the water through two or three perforated pipes in the centre. After the coal has been in each bunker for twenty hours or so it will be sufficiently dry to be discharged through trap doors in the bottom onto conveyors, which will deliver it to the coke ovens or into wagons. The time required for drying the coal by this system necessitates large storage bunkers, which add much to the total expenditure of the plant.

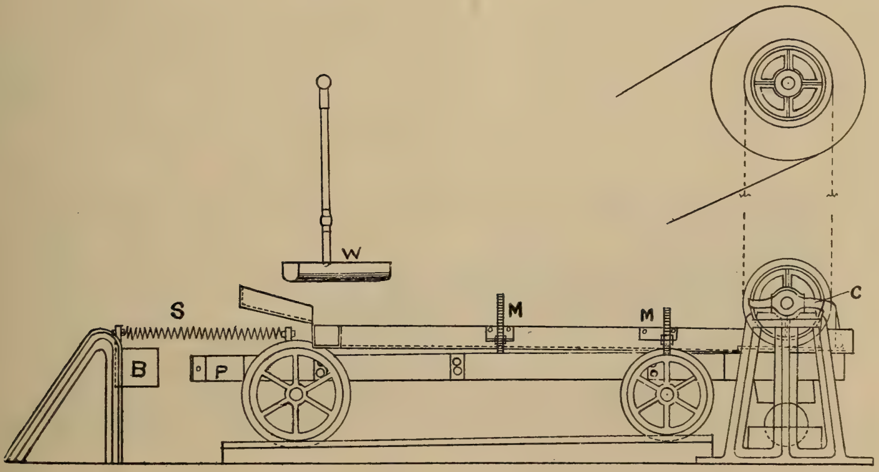
(2) The Dry System. The fine coal is drained by passing it over draining screens and conveyed in perforated elevator buckets and finally transported into hoppers, where it remains for some time to further drain. Another very satisfactory arrangement is an endless belt conveyor, the bottom and sides made up of perforated plates hinged to one another, thus forming a series of boxes. The whole belt running over rollers, spaced at different heights, so as to let the conveyor bend under the load of coal between one roller and the other, the effect of this sagging of the conveyor is to submit the coal to a process of pressure and expansion, thus facilitating the drainage. The dirty water which escapes and contains fine coal in suspension passes into a spitzkasten, where it gradually settles to the bottom and is afterwards recovered, and the water, clarified, is used over again.

### CYLINDRICAL DRYERS

A cylindrical dryer consists of a wrought-iron cylinder of a diameter and length depending on the output of fine coal it is intended to dry in a given time. The cylinder is mounted on rollers, which revolve at a suitable speed. The fine coal to be dried is charged at one end of the cylinder, and as it rotates the coal is



PLAN



ELEVATION.

FIGS. 14 AND 15.—BUMPING TABLES FOR TREATING AND PREPARING COAL INTENDED FOR THE CONVERSION OF COKE

conveyed from one end to the other of the cylinder by means of helical blades fixed to the inside. The coal can be delivered to a spiral conveyor. A furnace is located underneath the cylinder, and the hot gases and moist air are removed from inside the cylinder as rapidly as necessary by means of a fan. With this arrangement the coal is subjected to intimate contact with the hot gases and is under complete control of the man in charge, and the drying of the coal can be carried as far as desired. This system is adopted at the Cardiff washery.

### CONCLUSION

The cost of a washing installation is a matter very hard to determine, as it depends on the size, type of installation, location, class of buildings and the foundations required for the machines. The most that will be done in this paper will be to give the cost of a few existing installations and machines. Machines of the Coppee, Humbolt and Sheppard types cost very much the same for the same output.

A plant for dealing with 200 tons in a day of ten hours, including buildings, cost £4,000.

A plant capable of treating 500 tons in ten hours, including buildings, cost about £12,000.

A large Humbolt plant for dealing with 1,600 tons in ten hours, including buildings, cost £40,000.

Elliot washer, capable of treating 100 tons in ten hours, cost about £750.

Elliott washer, for dealing with 400 tons in ten hours, cost about £2,000.

A large Elliot washer, capable of treating 1,000 tons in ten hours, including buildings, cost from £5,000 to £10,000.

Craig washing plant, for dealing with 400 tons in ten hours, cost about £700.

# ELECTRIC DRIVING FOR MULE SPINNING

By **Albert Walton**

In a recent issue of this magazine the relative advantages of rope and electric transmission with individual motors for textile mills was discussed, and it was shown that the question demanded the exercise of skilled engineering ability and experience applied to each particular instance to determine the proper plan to be adopted. In the present paper Mr. Walton discusses the manner in which the difficult problem of driving the self-acting mule by electricity has been treated, and the results of experience are placed at the disposal of engineers and manufacturers.—The Editor.

OF the two methods of spinning yarns involving the use of "ring spinning frames" and "mules" or "jacks," the latter, though the older and more complicated, is so superior for certain classes of work that its simpler rival has never been able to entirely replace it. In the August, 1909, issue of this magazine we took up the subject of the power requirements of the ring frame in detail, and while we showed that the subject is not so simple as a superficial observation would indicate, the problem of properly driving the mule is vastly more complicated. This machine is a mechanical development of the old hand spinning-wheel methods, where the spinning and drawing are separated from the winding process, and while this is a relatively simple matter, with a single strand of yarn and a single spindle under control of the human hand and brain, it required wonderful ingenuity to construct a series of cams, gears, ropes, belts and levers to handle nearly a thousand strands and spindles at once, and that entirely automatically. The result—"Crompton's self-acting mule"—has come down through the generations as a machine fearfully and wonderfully made, full of strange starts and stops, reversals and accelerations, whose mechanism one cannot hope to fully comprehend but by months of apprenticeship and study.

It is these frequent changes that make the driving of a mule difficult. To comprehend the problem fully, it is first necessary to understand the cycle of operations as they occur under normal working conditions.

Referring to Fig. 1, which shows an end view of the essential parts of a cotton mule without the operating mechanism, it is seen that the prepared "roving," or coarse, partially twisted strands wound on bobbins, are mounted above and in front of the carriage on a rack or creel. The strands are brought forward over clearing bars to the feed rolls and then down between the "faller wires" to the spindle. This spindle, inclined at an angle of about 15 degrees toward the creel, is revolved at the proper time by a cord or "band" passing around a long tin driving cylinder to a small grooved pulley or "whorl" on the spindle. In the starting position the carriage is, as shown in the heavy lines, close up to the rolls, and all parts of the machine are standing still. The carriage now starts back very slowly, the spindles being almost instantly brought up to their full speed of from 6,000 to 9,000 revolutions per minute. Simultaneously the rolls start to draw the cotton from the creel, or the wool from the spools, and feed it out, the rate of feed being a trifle less than that of the retreating carriage. The distance the carriage travels to reach the position shown in the light outline varies from 48 to 60 inches. In woolen mules, when it has proceeded from two-thirds to seven-eighths of this distance the rolls stop feeding, the yarn being thus drawn for the remaining portion of the run back. In the outer position the carriage stands for a second or more while the spindles continue to revolve and put more twist in the yarn. The spindles now stop and reverse for three or four turns to unwind that portion of the yarn that has wound itself between the top of the spindle and the top of the cop or wound portion of previously-spun yarn on the spindle. The faller wires then assume the position shown in Fig. 2 and the carriage starts in, the lower wire rising and falling by just the right amount to guide the yarn onto the spindles, so as to properly form the tapering cop. The spindles during this run-in are revolving with just sufficient speed to take up the yarn and keep it taut as the carriage approaches the rolls. Here the faller wires resume their position as in Fig. 1, and the process is repeated.

Obviously the greater power is called for when the run-out commences and all the spindles have to be brought from rest to full speed in the first fraction of a second. The peak is so abrupt as to be in the nature of a blow. So sharp is it that the best belts will slip, the "shrieking" caused by the slippage being a sound almost inseparable from the operation of the larger mules. For the run-out the high rate of speed of the spindles consumes considerable power, about one horse-power being required for each fifty spindles. For an instant at the end of the stretch the power falls to nearly zero, and as the faller wires are moved the three reverse turns are made. During the run-in the spindles are revolving slowly, and, while the carriage travels much faster than in the run-out, the power is not great. The conventional power curve for a worsted mule, as shown by electrical instruments, is as shown in Fig. 3, though there are certain minor fluctuations with which we need not concern ourselves here.

The oldest method of driving groups of mules was by belting from a countershaft, which, in turn, was belted to the heavy main-line shaft, which was driven by belt or ropes from the engine, and this method is still being installed in mills where electric drive is not used. It is a very successful and simple system, the enormous momentum of the huge flywheel and mass of revolving shafts and machines being sufficient to absorb the violent peaks caused by the number of mules getting in step and starting at the same time. Without the momentum of the mill to call upon, no engine, already loaded up, would have sufficiently good overload speed regulation to prevent a very noticeable check in speed. That this momentum is called upon is a well-recognized fact, and is frequently advanced as the chief argument for the system. A close analysis of the matter may serve to throw another light on the case. The momentum or flywheel effect of any mass can be of assistance in absorbing sudden peak loads only by surrendering part of its stored energy to the part making the demand. It can give up this energy only by reducing its velocity. The greater the mass the less will be the reduction in speed called for to supply a given demand, but an increased mass means only a greater volume of shafting and machinery. Thus, while we increase the momentum to help out, we also increase the number of machines to be affected. The eye and ear cannot detect a speed variation of plus and minus 5 per cent. from the normal, which is of only a few seconds' duration, and until recently this fluctuation was not known to exist. The elaborate tests of Mr. William Woodhouse in English cotton mills with a specially devised and very sensitive speed-recording instrument have shown that double this variation is suffered many times in a period of five seconds in an engine-driven mill. (Westinghouse Electric & Manufacturing Company, "Textile Motor Talk" No. 10.) This fluctuation is

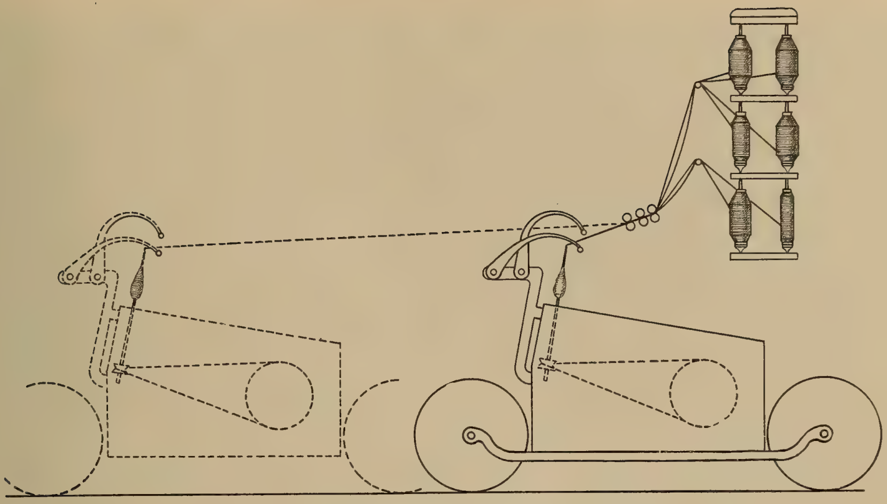


FIG. 1.—OUTLINE SKETCH OF END VIEW OF MULE

Showing relative positions of creel, rolls, carriage and faller wires at beginning (solid lines) and end (dotted lines) of run out.

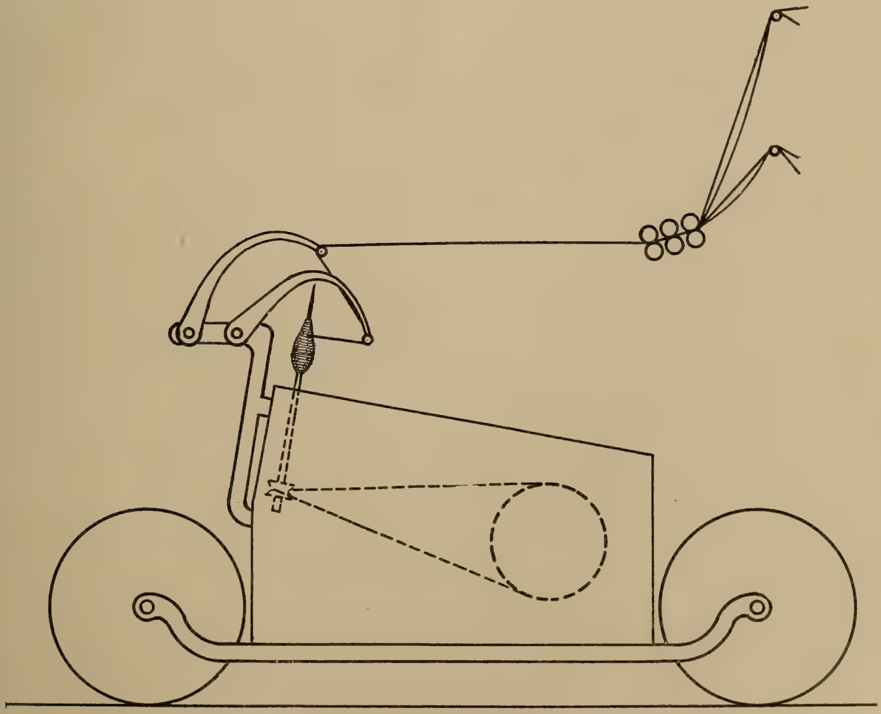


FIG. 2.—POSITION OF FALLER WIRES DURING RUN IN

Carriage moving toward drawing rolls. Yarn being wound on the spindles.

reflected on every machine in the mill, although to the eye they are running at the absolutely constant speed the work demands. When it is realized that the mules are making from one to five complete cycles each minute, the frequency of the occurrence of these vicious surges may be appreciated. Furthermore, it should be stated that approximately half the power required by the mill is used in the spinning room. Thus, a sudden increase of even 25 per cent. of the demands made by the mules means no less than an eighth of the entire power for the mill to be superimposed on an already fully loaded system, and yet the peaks will frequently be found to exceed this percentage. To obviate this difficulty, certain mills have separated the mule drives from the preparatory processes and the weaving by driving them by a separate engine. While this relieves the situation for the other machines, it aggravates it for the mules by the loss of momentum, nullifies the argument for the large-unit drive, and creates an entirely new problem.

This separation has more frequently been accomplished by use of electric motors in one way or another. In at least one New England mill the mules are driven as a group by ropes from one engine. It is a yarn mill, and the mules occupy two entire floors, while the preparatory processes occupy a third. As there is no weaving, this means that the mules constitute two-thirds of the total load and the fluctuations form a proportionately greater percentage. With the steadying effect of the weave room lacking, it was thought best to insure a steady speed for the drawing frames, combers, roving frames, etc., by the use of motors. A second engine is direct connected to an alternator, which drives motors of from 20 to 150 horse-power, distributed over the floor where the preparatory machines are installed, driving them in suitably large groups.

Other large mills employ motors throughout. In most cases the mules are arranged in groups of four, six or eight to each motor. Small worsted mules average about 3 horse-power each, and the large cotton mules will average about 8 horse-power apiece, so the motors vary in

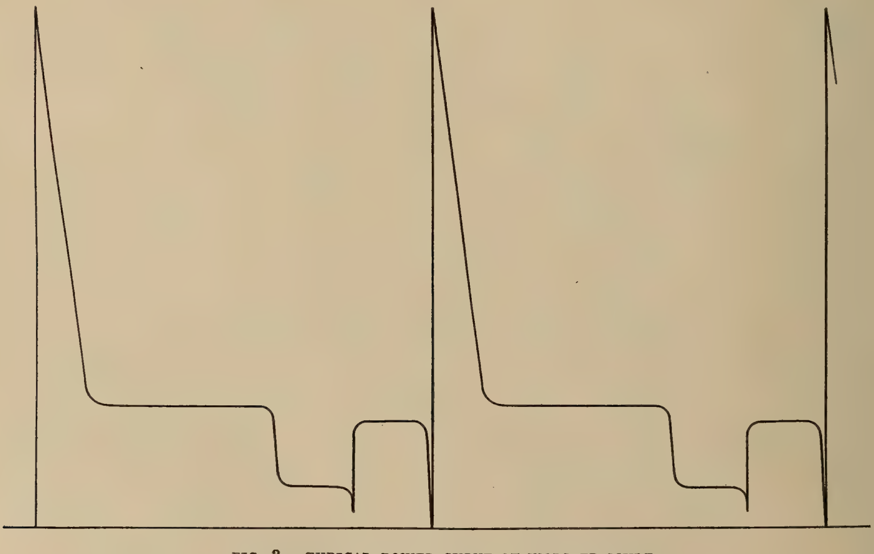


FIG. 3.—TYPICAL POWER CURVE OF WORSTED MULE

Showing the peak due to acceleration of spindles, power during run out, putting in twist and run in.

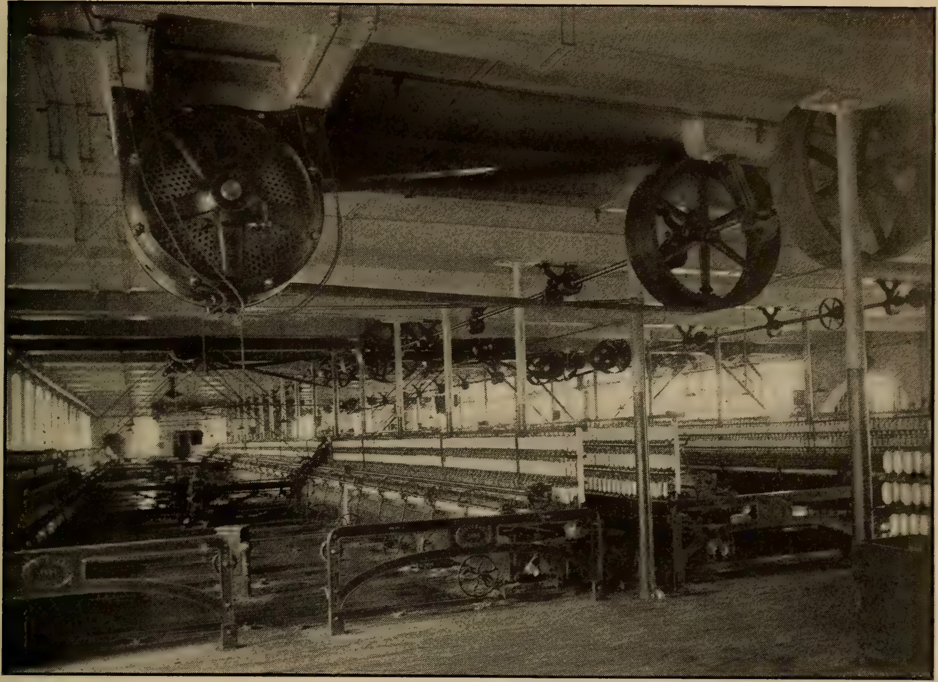


FIG. 4.—A CAREFULLY-ARRANGED ROOM WHICH EMPLOYS MOTORS OF 50 AND 70 HORSE-POWER

size from 10 horse-power to 150. The most carefully arranged room that has come to the writer's attention employs motors of 50 and 70 horse-power, driving groups of three and four mules, respectively, the surplus power being designed to care for the peaks which occur when the mules get "in-step" (Fig. 4). To further assist in providing for these emergencies and to provide a substitute for the old mill momentum, a 600-pound flywheel is placed on each countershaft, from which a mule is driven. These are 30 inches in diameter and make about 350 revolutions a minute. This weight, combined with the mass of the short stretches of shafting and the necessary pulleys and the momentum and overload capacity of the motor, provides a very successful drive. That these flywheels are not a necessity, however, may be seen from the accompanying photograph, where a similar and equally successful drive is shown without other momentum than the driving parts. This installation has been in daily operation for the better part of a decade with most excellent results. As will be shown later, the use of flywheels is at least open to question. Such difficulties as have arisen in applying motors to group drives have come from providing an insufficient reserve power in the motor rather than from lack of momentum in the transmission.

As in other power problems, the most intimate knowledge of the requirements of the situation has come with the application of the individual motor. At least one woolen mill has adopted this method on all its mules and has had it in operation for several years. Recently several other mills, both East and West, have taken up the matter seriously in connection with the recent extension of individual drive in other departments of the textile industry. Considerable experimenting has been done with various forms of motors, and a wide variance of opinion exists as to the merits of the drives involved. Three distinct types are contesting for supremacy and are raising some interesting questions in engineering. One of the large electric companies is consistently recommending a motor with very good speed regulation and with a 250-pound flywheel mounted on the motor shaft on one side, while on the other is a wide-faced pulley, from which belts run to the mulehead (see Fig. 5). Another large electric company makes one of two recommendations, according to conditions, but no flywheel is used in either. In cases where speed considerations will permit it a slow-speed motor of moderately good speed regulation is used and belted directly to the mule. In installations where this method cannot be used to advantage a high-speed motor is belted to a countershaft driving the mule. The recommendations of the engineers are so radically opposed that it is interesting to see how each justifies his opinion. One advances the following reasons: The load is a violently fluctuating one, running from zero to four times average value. It is eminently desirable that the speed of the drive be as little affected by these fluctuations as possible, in order that the spindles and drawing rolls may revolve at a constant speed while the spinning is in progress, or from start to finish of the run-out. As an induction motor has the property, inseparable from its design, of falling off in speed under load, it cannot be expected to remain unaided at constant speed when such a violent momentary overload is forced upon it; but with a heavy, high-speed flywheel it can meet this instantaneous call with little or no appreciable check in speed. Furthermore, the flywheel smooths out the load curve from an electrical standpoint, and a much less severe peak is imposed on mains and generators than would be the case if it were omitted. Consequently, also, the motor capacity may be less, and only the necessary size to care for the average load need be provided.

The arguments brought in support of the yielding drive with lower speed regulation and no flywheel are no less interesting. It is held that the flywheel and close-speed regulation defeat their own ends. A large amount of power is required to accelerate so many spindles with their cops of spun yarn from rest to, say, 7,500 turns per minute in a single second, while probably more than four times this would be required to do this in half a second. As a matter of fact, no matter how much power one could apply to the driving cylinder, it is doubtful if better or even as good results as this could be obtained, since the inertia of the spindles will cause the small driving bands to slip momentarily on the spindle pulley or "whorl" if too rapid acceleration is attempted. But if this were not the case and the perfect speed of the flywheel motor could be imparted instantly to the spindles, as its supporters believe to be true, it would be an example of "the immovable body being struck by the irresistible mass." Something would have to give. Following this line of argument, its supporters hold that the motor should give way at this crisis somewhat, though not too much. By easing over this point and relying on the inherent overload capacity and high "pull-out" properties to supply to the belts, ropes and bands as much power as they are capable of carrying, they are disposed to assert that the net result will be a quicker acceleration of the spindles than with the irresistible flywheel drive. They also believe that the poorer regulation of the motor is not a detriment in the spinning, since, once the spindles are accelerated, they provide a constant load until they reach the end of the stretch; and a constant load means a constant speed, no matter what the regulation may be. The fact that the motor speed is slightly higher during the run-in than during the spinning is held to be no detriment, but rather an advantage, the two actions being entirely indepen-

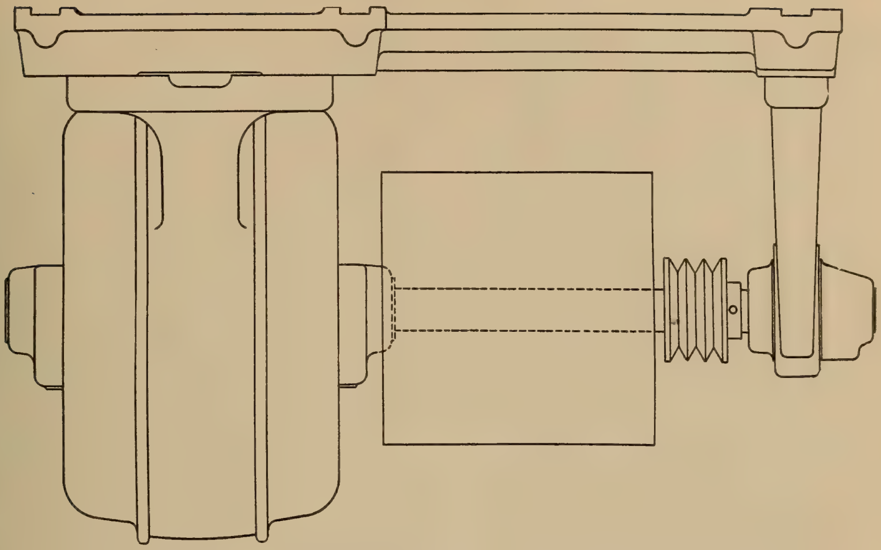


FIG. 5.—OUTLINE OF SPECIAL MOTOR FOR DIRECT BELT DRIVE TO WORSTED MULE

dent of each other and the run-in being practically lost time, like the return stroke of a shaper or planer in a machine shop .

Just how the two work out in practice the writer had a very good opportunity to observe recently where a demonstration of both methods was in progress. The mules were identical in all details of construction, and both were spinning No. 50's, soft worsted yarn, with all the adjustments made as nearly the same as possible. Both motors were on the same mains of a three-phase, 60-cycle, 550-volt circuit, and both were 6-pole, 15-horse-power motors with a no-load speed of 1,200 revolutions per minute, built especially for this demonstration. One carried at one end a 250-pound flywheel, and had a rated full-load speed of 1,140, or a slip of 60 turns, 5 per cent. of the no-load speed. The other had no flywheel, and had a full-load speed of 1,080 revolutions per minute, or a slip of 10 per cent. The pulleys of both motors were the same diameter, 10 inches, and the same results were shown with both paper and iron pulleys. Five minutes' observation made simultaneously on the two motors showed that the flywheel motor exceeded the other in average working-load speed by 2 per cent., yet the mule driven by the slower motor made seventeen trips while the mule driven by the flywheel motor was making sixteen. Thus, in spite of a 2 per cent. slower motor pulley speed, it was running 6 per cent. faster by actual count. To check up the theoretical explanation it was only necessary to climb a ladder to a point near enough to the motor to hear distinctly the click of the belt lacings as they passed over the motor pulley. On the flywheel type motor when the peak occurred it was observed that the pulley continued to revolve with apparently undiminished speed, but lost its tractive power on the belts by very bad slipping. The clicking of the belt lacing dropped from its regular speed instantly, the next trip of the belt taking certainly twice as long as the normal period and the next nearly as long, while from then on the trips rapidly resumed their normal time. The sound of slipping was very noticeable, and the pulley was very hot from friction. A similar observation made at the pulley of the other motor disclosed no such state of affairs. A slight slip at the mo-

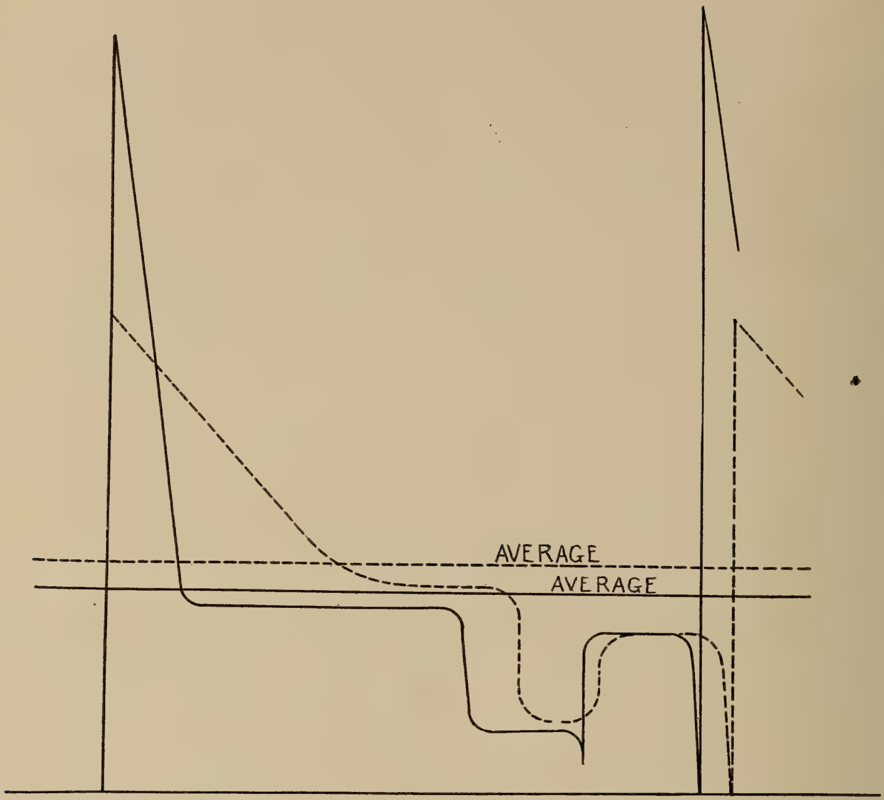


FIG. 6.—CURVES SHOWING EFFECT ON POWER REQUIREMENTS DUE TO USE OF FLY-WHEEL ON MOTOR DRIVING MULE OF 600 SPINDLES

Solid line shows power input to motor without fly-wheel; dotted line for motor with fly-wheel.

ment of starting occurred, but the extra load pulled the motor speed down to a point where it could hold the belts. The inherent overload power of the motor delivered to the belt which was then adhering to the pulley enough more power than the other motor could transmit to the slipping belt to bring the whole machine to speed much more quickly.

Further importance attaches to this feature by reason of the fact that the carriage and all the auxiliary are controlled by the belts, while in certain types of mules the spindles are driven through a separate system by small ropes over a grooved pulley on the motor shaft. Although subject to the same sort of slipping, the ropes will slip to a different degree from the belts, and the twist put into the yarn will not be the desired amount. When the slip of the belt is reduced, as with the motor without the fly-wheel, this feature is practically eliminated. On the usual cotton-mill mule the rope drive for the spindles does not go back to the motor, but receives its power through the belts, so that the principal gain for these machines in eliminating slip is in production.

The accompanying curves are roughly representative of the power history of the two systems (see Fig. 6). They are average values from a large number of readings on an indicating wattmeter at intervals of two seconds. These were checked by a like number of observations on the time required by the mule carriage to execute the various parts of its cycle. Although such a method cannot be absolutely accurate, it shows conclusively that while the flywheel effectively cuts down the electrical peak it does so by prolonging the reduced maximum to such length that the net result is a greater power demand than is required by the other motor, thus defeating its purpose in this respect, as well as in the main object of its use.

There is also the objection that a number of motors suspended from the ceiling, each with a 250-pound balance wheel revolving at such high rate of speed, provide an element of danger that might well be eliminated. In one instance within the writer's knowledge one of these flywheels was dislodged in the course of regular operation and fell to the floor, bringing up violently against the mill wall after a short and rapid trip across the floor, with, fortunately, no more serious results than a broken floor and a dented wall.

It seems, then, that when motor drive is used a motor that will yield somewhat in speed is a better engineering proposition than the flywheel type with a very high speed regulation. In the attempt to reproduce the old conditions of great momentum in the drive one vital feature was overlooked. The high speed of the motor necessitates a pulley of smaller diameter than the mule pulley, and this introduces a new problem, which is solved by introducing a new feature in the driving system. With the old shaft drive the counters run about 350—too slow for an electric motor,—and the pulleys are, consequently, 36 inches or more in diameter, which prevents any slippage except at the mule pulleys themselves. Thus a great deal more power can be transmitted at the instant of impact than with the unyielding motor. In spite of this, however, and owing to features already brought out in the early part of this article, either of these motor drives will produce more yarn than will the large and fluctuating group system.

A third system is a combination of the two and retains the good features of both. This employs simply a constant-speed standard textile motor driving the old countershaft above the mule. This retains the large driving pulleys and permits the use of a high-speed motor of no "special" design and obviates all necessity for balance wheels. It is our opinion that this is the drive which will be proven most successful in the long run. In a recent competitive demonstration of the two systems this latter drive was finally adopted as yielding greater production of more uniform yarn and involving not over two-thirds of the first cost, including countershafts and belts.

Thus, as usual, the most successful application is found by retaining as many of the good features of the old and tried methods as possible while bringing as many of the undoubted advantage of the new as may be.

# SUPERHEATED STEAM AT SEA

By P. C. Ashford

THE question of the employment of superheated steam at sea is almost as old as marine engineering itself, and at any rate it is something like fifty years ago since it was first broached, but up to within the last few years no great success had been obtained, for reasons which will be explained later. Speaking generally it may be said that any complication of machinery—and superheaters should be classed to some extent in this category—must be more than justified by practical resultant economy if its adoption is to be successful; in other words, no theoretical efficiency is of any value unless the sum total of gain to be effected is still an appreciable one, after allowance has been made for all the commercial conditions which affect its value, such, for instance, as the question of reliability, extra cost of maintenance and supervision, interest and depreciation of the plant and many other matters which are involved by any addition to existing machinery.

In very few cases is this principle so well exemplified as with superheaters. Since the early fifties it has been as clearly recognized as it is to-day that a large increase in efficiency should be possible of attainment in steam plants by superheating steam above its normal temperature of evaporation, and no doubt has ever been expressed as to this saving being of sufficient magnitude to be warrantable, provided the difficulties it involved could be satisfactorily overcome. The object in employing superheated steam with reciprocating engines is chiefly to eliminate the wasteful condensation of steam and the consequent loss of heat in the cylinders, and this can only be satisfactorily accomplished by admitting steam at such a temperature that it can give up sufficient heat to raise the temperature of the cylinder walls, and not lower its own temperature in so doing to below the point of evaporation.

The first difficulty encountered in the old days was with the construction and operation of the superheater itself, and after that had been more or less satisfactorily overcome there remained the very important question of the deleterious effect of the high temperature steam on the lubricating oil for the valves and cylinders which for the latter was quite essential in comparatively large quantities, since there was no water in the cylinders to affect the lubrication. This naturally called for a better class of oil with a high flash point and, moreover, necessitated efficient filters for separating the oil from the condensed steam, before returning it to the boilers. In land installations this has for many years been successfully accomplished, but at sea the matter is rather different. Space for the oil filters is not easy to find, and the type which is suitable for a spacious engine room on land is scarcely the one to adopt at sea, while the engineers on ships have their time more fully occupied and the changing of filter cloths, etc., is not to be done in a few seconds. Perhaps these objections would not have proved sufficient to prevent the adoption of superheating at sea were it not that a further obstacle presented itself, namely, the serious effect which the presence of salt in small quantities in the feed water had on the superheater tubes, this salt being due to the leakage of condenser water which entered the boilers with the feed water. Weighing all these considerations, shipowners and marine engineers seem to have decided that superheating at sea had not proved itself a commercial success.

The last five or ten years have, however, seen a considerable change. Superheating on land has received a great fillip by the introduction of steam turbines for practically all large installations, and in these the entire absence of oil at once discounted the chief objection to the use of superheat, though the gain in economy is not so great as with reciprocating engines. At sea, moreover, the main objections to the employment of superheated steam have automatically worked themselves out. Boiler pressures are higher, boiler construction is better, and care is now invariably taken to exclude salt from the feed water, with the result that superheaters do not suffer damage and can now be considered as reliable for long service as inland boiler installations. Oil filters of very much improved type have been constructed so efficient as to practically free the water from oil, and the quality of the oil itself has been so improved as to suffer no harm from the high temperature of the steam. The result is that at the present time the number of ships equipped with superheaters is somewhere in the neighbourhood of five hundred, though it must be admitted that the majority of these are relatively small vessels, but include, nevertheless, at least four German and several American warships of over 20,000 horse-power within the last two years.

The introduction of the steam turbine for ship propulsion will finally have an important bearing on the employment of superheat for marine work. Turbines are ideally adapted for the purpose, as is proved by the invariable use of superheated steam with such installations on land, since the only difficulty encountered (the trouble with oil) is non-existent. Marine turbines, however, are not quite on the same footing as land turbines, chiefly because of the slow speed of revolution necessitated by the present limits of propeller efficiency, and hence, in the early days of marine turbine development it was deemed inadvisable to install superheaters, chiefly because of a slight extra possibility of blade stripping, owing to the higher temperature. However, this fear seems to have now been removed and one large reaction turbine war vessel of the German navy, the *Dresden,* with engines of 20,000 horse-power, has now been in commission two years, using 50 degees of superheat. Mr. Parsons has himself recently stated that superheat up to 50 degs. F. may safely be used, while with slight modification of design superheated steam up to 100 or 150 degrees may be employed.

TABLE 1

| Ship Owner, Name of Steamer, Type of Engine and Boiler Plant. | Steam Temperature, Deg. Fahr. | Economy in Fuel. |
|---|---|---|
| Oldenburg Portuguese Company, average of twelve, triple-expansion, 600-900 horse-power; two boilers with two furnaces | 610-660 | 15% |
| Argo Line, Bremen, average of eight, triple-expansion, 700-1,000 horse-power; two boilers with two furnaces | 620-660 | 13-18% |
| Argo Line, Bremen, S.S. *Schwan,* triple-expansion, 1,125 horsepower; two boilers with Howden's forced draught | 610 | 13% |
| Norddeutscher Lloyd, S.S. *Erlangen,* triple-expansion, 2,600 horse-power; two single, one double boiler | 660 | 12% |
| Levant Line, Hamburg, S.S. *Volos,* triple-expansion, 800 horse-power; two boilers with two furnaces | 610 | 20% |
| Moss Werft, S. S. *Trave,* compound engine; one boiler with two furnaces | .... | 25% |
| Norden Geldske Dampskibsselskab, Trondhjem, S.S. *Präsident Christii,* compound engine; one boiler with two furnaces | 600 | 18.9% |
| McAndrew & Co., London, S. S. *League,* triple-expansion engine; one boiler with four furnaces | 560 | 21.2% |
| Cie. Generale Transatlantique, S.S. *La Garonne,* triple-expansion, 1,300 horse-power; two boilers, each with three furnaces, forced draught | 600 | 15% |
| Chargeurs Reunis, Le Harve, S. S. *Amiral Jaurigebery,* triple-expansion; three boilers, each with three furnaces | 560 | 14.5% |

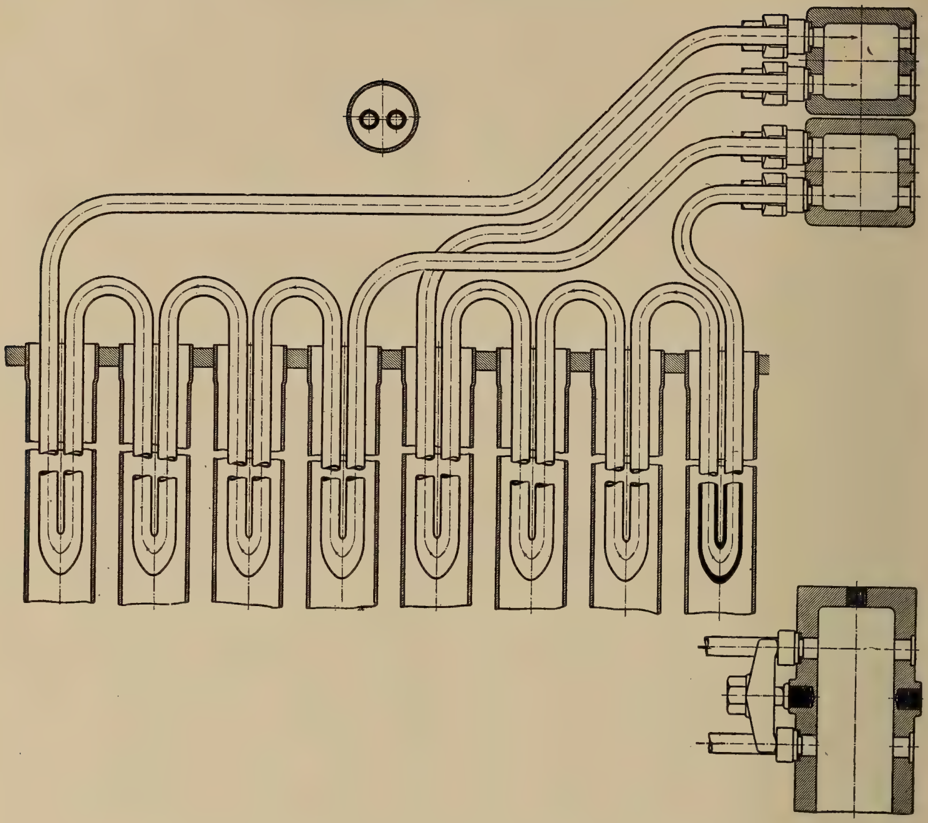


FIG. 1.—DETAILS OF SCHMIDT PATENT SMOKE TUBE SUPERHEATER

Impulse turbines for marine work are, of course, used only to a very small extent, but it is noticeable that in nearly every instance superheaters have been installed in conjunction with them, and without laying too much stress upon the point it may, generally speaking, be stated that this type of marine turbine is better adapted for superheat—at any rate, for high degree of superheat—than the reaction turbine on account of the earlier drop of temperature as the steam expands and the larger blade clearances. Since the impulse turbine is admittedly not so efficient at its low pressure end as the Parsons type, there is a strong probability of the development of a modified form—namely, a turbine with a high-pressure velocity compounded stage and the remaining stages with the ordinary reaction blading—in which case it would be safe to use superheats up to 200 degs. F., or even more. This development has indeed already been foreshadowed by Mr. Parsons himself.

The economy to be realized by the employment of superheated steam in marine engines depends naturally upon the degree of superheat, and, to some extent, upon the type of boiler and superheater installed, but it may be taken as a conservative estimate that with reciprocating engines and the ordinary boiler pressures every 100 degrees superheat decreases the coal consumption by 8 or 9 per cent., while with steam turbines the economy is in the neighbourhood of 6 or 7 per cent. It is interesting to note, moreover, that the percentage economy in coal consumption will, with a properly designed superheater, be actually greater than in the steam

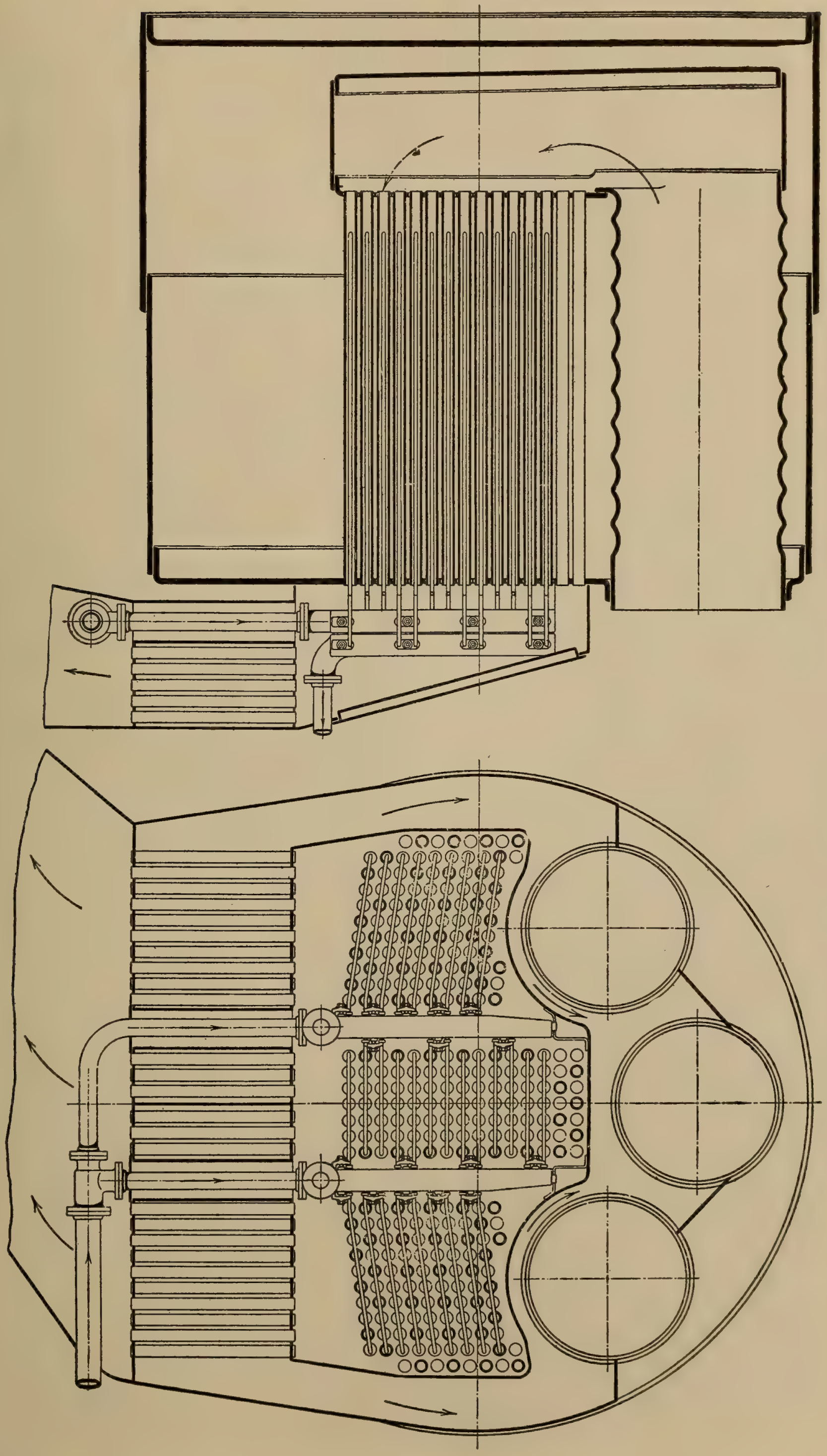


FIG. 2.—THREE FURNACE BOILER WITH FORCED DRAFT, FITTED WITH SCHMIDT'S SMOKE TUBE SUPERHEATER

itself, since the efficiency of the boiler is increased, owing to the baffling effect on the gases, due to the superheater—this applying naturally only to superheaters which are an integral part of the boilers and not to the separately-fired type, where the comparatively low efficiency lessens the overall economy. There is a large number of vessels, particularly German, which, originally designed to use only saturated steam, have been afterwards adapted for superheaters and superheated steam, and some interesting results have been obtained as to the difference in fuel consumption under normal steaming conditions. *La Garonne,* a vessel owned by the Compagnie Générale Transatlantique, with a triple-expansion engine of about 1,300 indicated horse-power, was fitted with a superheater of the Schmidt type to give about 200 to 220 degs. F. superheat, and it was found on an average over a long run that whereas with saturated steam the coal consumption was 1.59 pounds per indicated horse-power-hour this was reduced to 1.25 pounds with superheat, or a saving of 21 per cent. Another vessel, the *Lowenburg,* with engines of 1,750 indicated horse-power, effected a saving of 16 per cent. in coal, with about the same degree of superheat. A comprehensive list of the actual results obtained by the use of the Schmidt superheater is given in Table 1, and from this shipowners can gain a fairly accurate idea of the possible economy in various classes of ships.

Coming nearer home we have ample proof of the economy of superheaters in the tests carried out a few years ago by the British Admiralty on the *Britannia,* which was fitted with Babcock & Wilcox superheaters. It was found as a result of the trials that with 83 degs. F. superheat at the engines a decrease in steam consumption of 13 per cent. was obtained, and had it not been for the fact that after the time of these trials the steam turbine was exclusively adopted for war vessels, there is little doubt that superheaters would by this time have been largely adopted on battleships.

Some time ago a very complete set of trials were carried out on the steamer *James G. Wallace,* owned by the Acme Company, U. S. A., Babcock & Wilcox superheaters being fitted to the boilers. The engines were capable of developing about 1,600 indicated horse-power when the vessel's speed was 12½ knots. It was found on a test lasting fourteen hours that with saturated steam the coal consumption was 1.78 pounds per indicated horse-power-hour, while with 84 degees superheat it was reduced to 1.57 pounds, a saving of nearly 12 per cent. with this low degree of superheat.

The *Mainz,* a German cruiser, equipped with A. E. G. Curtis turbines of 26,000 horse-power, is fitted with separately-fired superheaters, and though no figures are available for the steam consumption with saturated steam it was found that when developing 8,000 horse-power the steam consumption with a superheat of 80 degs. F. was 6.54 kilograms per horse-power-hour, while with 170 degrees at the same power the consumption was 6 kilograms per horse-power-hour, showing a saving of 9 per cent. for an extra 90 degrees superheat.

There are practically only two types of superheater of any importance in use for marine work—the Schmidt superheater and that of the Messrs. Babcock & Wilcox, the former being especially applicable to Scotch boilers and the latter to water-tube boilers.

The Schmidt superheater, which is shown in Fig. 1, consists essentially of a series of tubes fitted inside the smoke tubes, conveying the steam after it comes from the boilers. The saturated steam is delivered into collector pipes or headers, usually fixed vertically at the back of the boiler, from which it is led through the pipes already mentioned placed in the smoke tubes, and thus the steam becomes

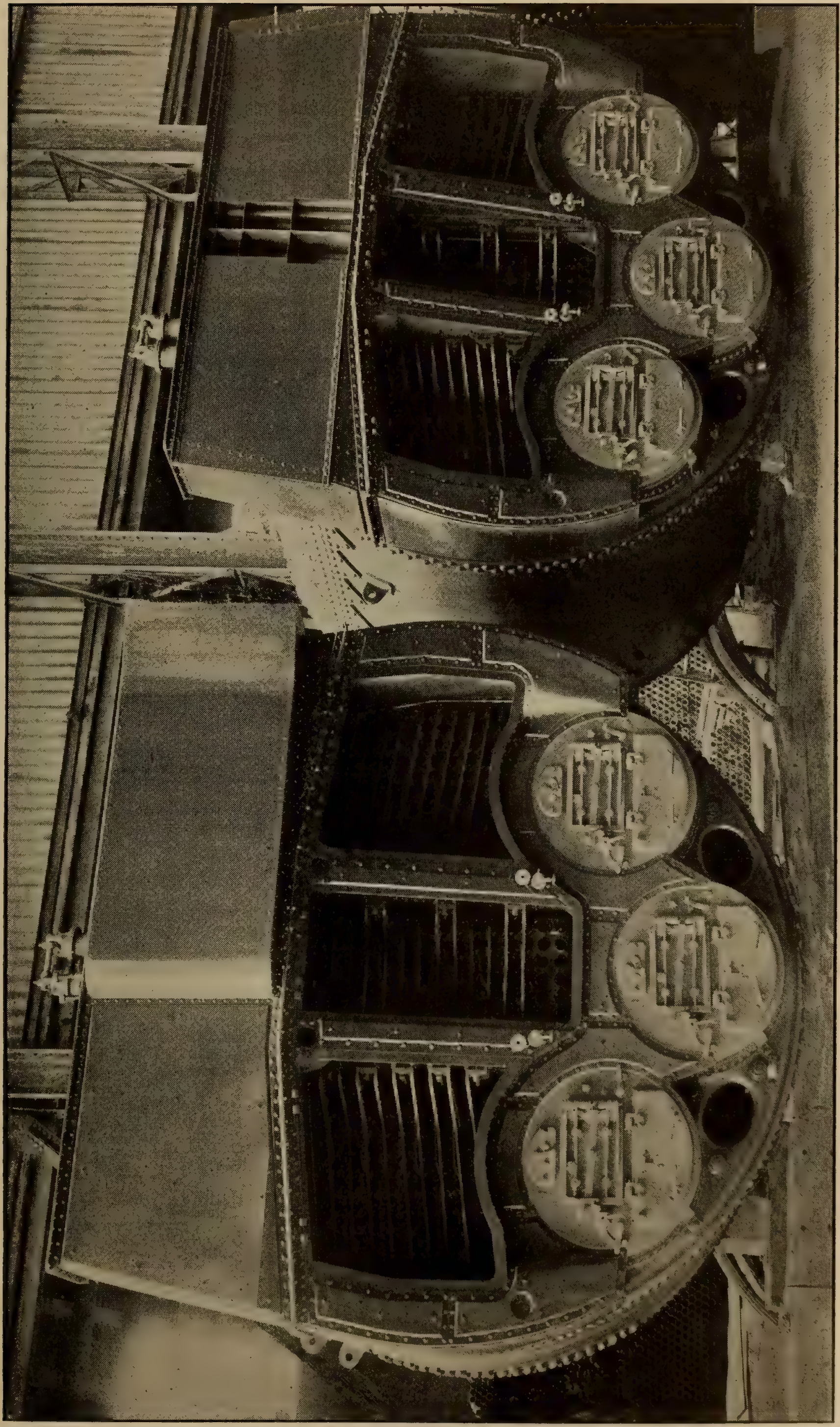


FIG. 3.—BOILERS OF THE STEAMSHIP ERLANGEN, WITH SCHMIDT SUPERHEATERS

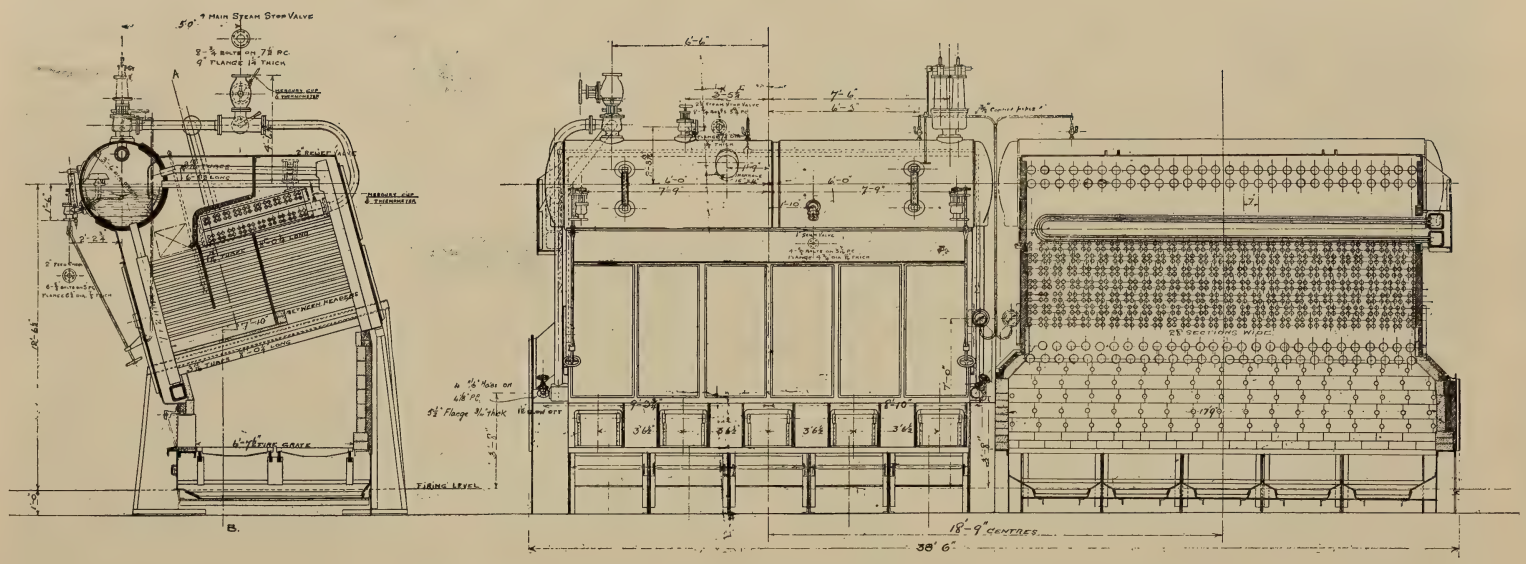


FIG. 4.—ARRANGEMENT OF TWO BABCOCK & WILCOX MARINE TYPE BOILERS, FITTED WITH SUPERHEATERS

| | |
|---|---|
| Tube-heating surface in two boilers | 7,350 feet |
| Grate area in two boilers | 235 feet |
| Superheater surface in two boilers | 1,016 feet |
| Working pressure | 300 pounds per square inch |

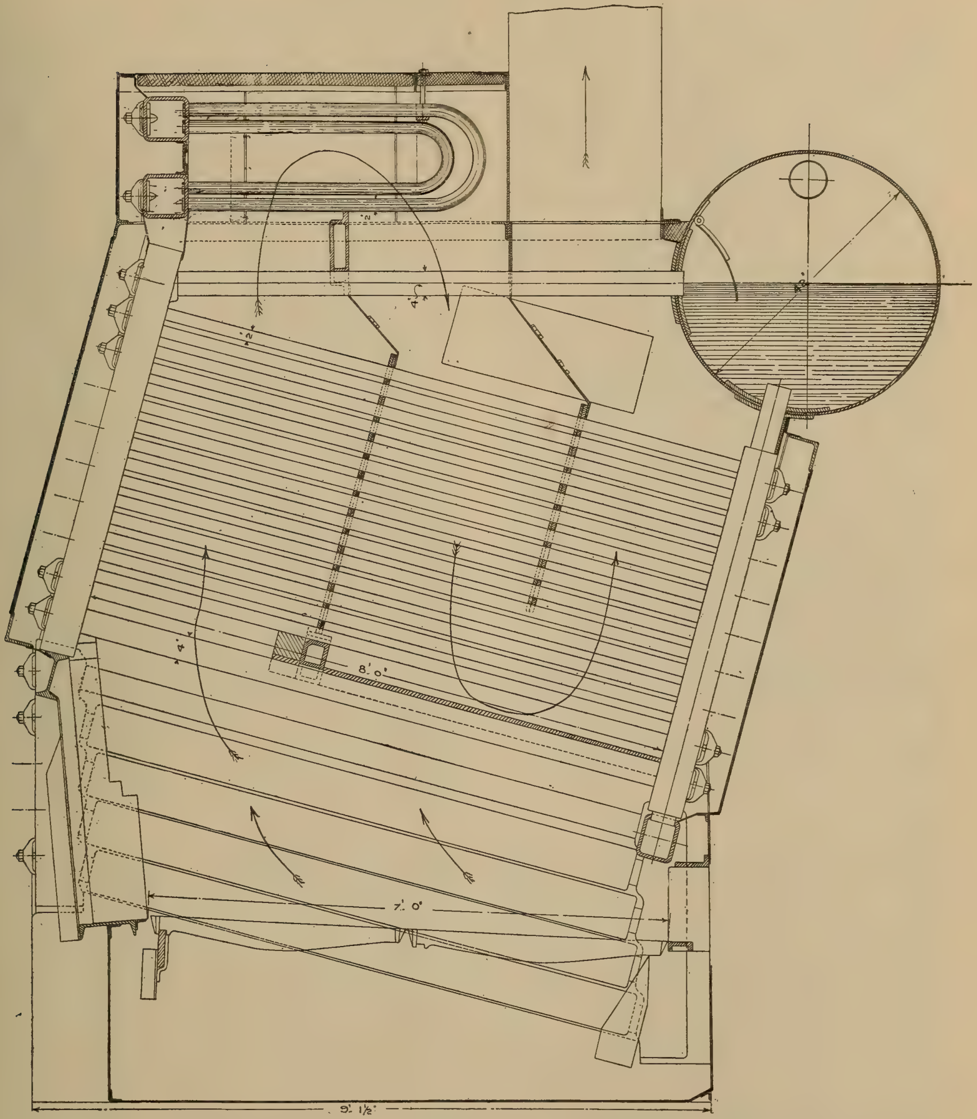


FIG. 5.—BABCOCK & WILCOX BOILER WITH SUPERHEATER, U. S. S. NORTH DAKOTA

superheated by contact with the furnace gases, being delivered into common collector tubes, from which it is taken to the engines. It might be thought that the introduction of steam-carrying pipes in the smoke tubes would cause a considerable reduction in the draught through the tubes, but, as a matter of fact, the reverse is the case. In the first place the area of the steam tubes is but a small proportion of that of the smoke tubes, as is seen from the illustrations; and, moreover, the working grate area is relatively more reduced than the smoke tube area, due to the diminution of coal consumption, and thus the ratio of smoke tube area to grate area is actually larger in boilers fitted with these superheaters than when they are not employed. Fig. 2 shows a three-furnace boiler fitted with a Schmidt superheater, while in Fig. 3 is seen one of the boilers of the steamship *Erlangen*—a Norddeutscher-Lloyd boat of 2,600 horsepower—in which the superheater pipes and the general arrangement of the superheater are clearly indicated.

The Babcock & Wilcox superheater for marine work is employed solely for water-tube boilers, and has within the last few years made remarkable progress, particularly in America, where marine engineers and shipowners are perhaps not so much hampered with preconceived notions regarding the unreliability of superheaters. This superheater is not unlike the same firm's well-known superheater for land boilers. Fig. 4 shows the general arrangement of two Babcock & Wilcox marine boilers fitted with superheaters capable of giving a superheat of 300 degs. F. and with a mixing valve allowing the temperature to be varied according to the amount of superheated and saturated steam in the mixture. As is seen, the superheater tubes are placed immediately above and at right angles to the main tubes, though in Fig. 5, which gives a view of the superheater on the U. S. S. *Prometheus,* they are parallel. This was, however, an earlier design and the arrangement shown in Fig. 4 is now always adopted. The number of tubes varies to some extent,, but the proportion indicated in Fig. 4 is a fairly general one, the heating surface of the superheater being approximately one-seventh of the boiler-tube heating surface. The superheater tubes directly above the main tubes are connected to two main headers, one of which receives saturated steam from the boilers and the other delivers super-

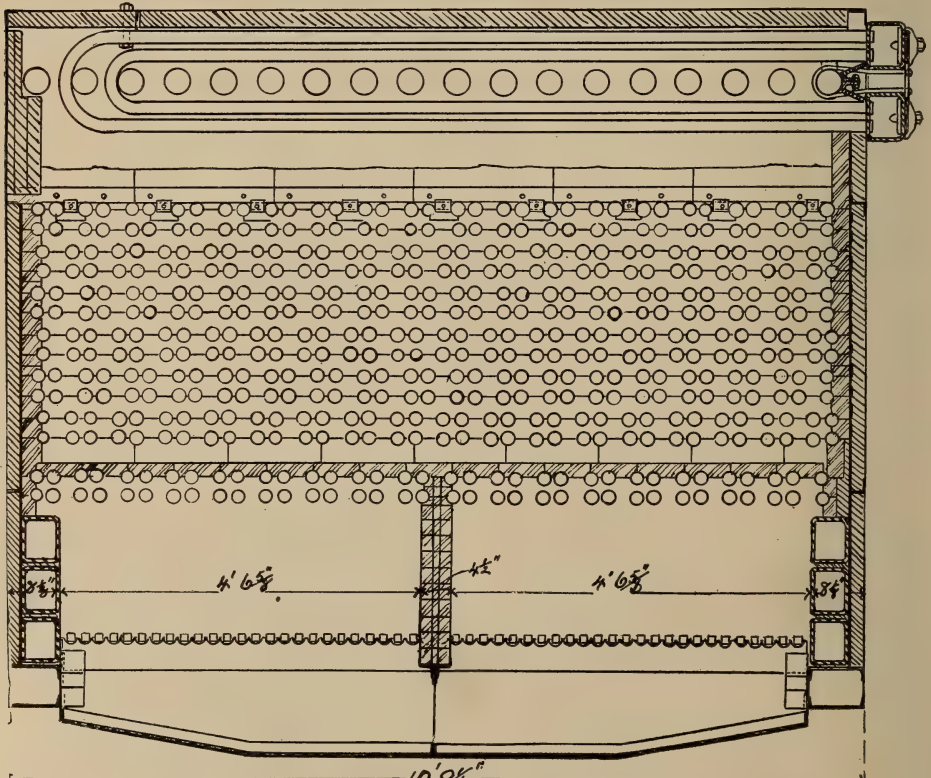


FIG. 6.—A SINGLE BABCOCK & WILCOX BOILER WITH SUPERHEATER

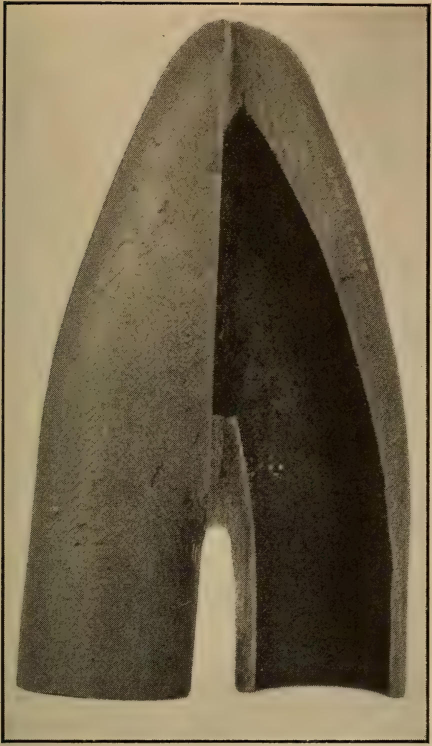


FIG. 7.—TUBE END OF A SCHMIDT SUPERHEATER, SHOWING THE MANNER IN WHICH THE METAL IS THICKENED TOWARDS THE POINT

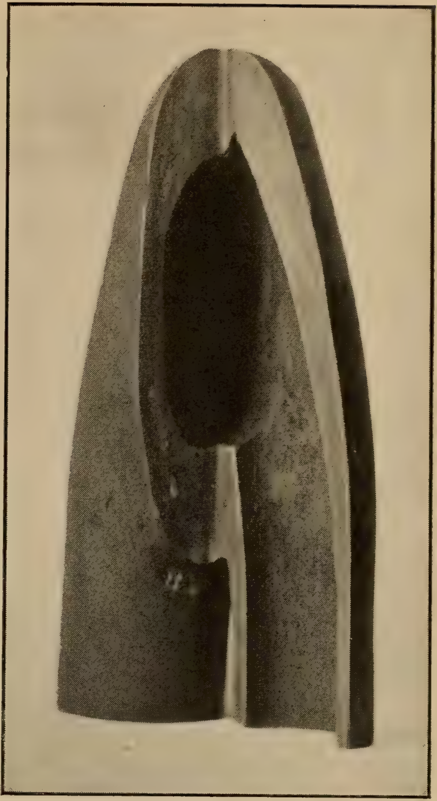


FIG. 8.—TUBE END OF A SCHMIDT SUPERHEATER

heated steam to the engines after it has passed through the superheater. Fig. 6 shows a single Babcock boiler with superheater as arranged for a small yacht with an engine of about 500 indicated horse-power, and in this ship it was found by careful tests under normal running conditions that the reduction in coal consumption, due to 100 degs. F. superheat, was almost exactly 10 per cent.

One cannot be accused of undue optimism in stating that the future outlook for the employment of superheated steam at sea is a very rosy one. It is always the first step which counts most, and this, as has been shown, has already been successfully taken, both as regards large ships and small. The continued development of turbines, particularly of the combination type foreshadowed above, will do much to bring about the desired consummation, but as also the major difficulties have been overcome in the case of reciprocating engines very rapid developments may not unreasonably be now anticipated.

# THE GREAT TRANSFORMATION

By Henry Harrison Suplee

## VII.—AVIATION AND EXPLORATION

THERE is probably no department of active work which demands free and unimpeded movement more urgently than that including the investigation and exploration of the less accessible portions of the surface of the earth.

Originally the more highly developed localities were those which could be reached by water—the seaports and the banks of the unobstructed rivers. The entire perimeter of the Mediterranean was taken up by the development of Rome before Cæsar penetrated through Gaul to the Channel and the North Sea, while distant points in the interior were reached only with difficulty and hazard. Warfare, down to the period of the introduction of railways, followed the slow movements of the march of men upon the surface along limited roads, and to-day the military highways of Cæsar and Napoleon indicate the immense task involved merely in getting about.

Apart from the use of waterways for commercial transport of a few, painfully-built high roads for overland travel, and of the caravan routes over the desert from the Orient, the world long remained a sort of unexplored wilderness, civilization being limited to the points which could be served by these few means of transport and communication.

After the revival of activity in ocean exploration, bringing with it the discovery of America, the opening of the sea route to India and the circumnavigation of the globe, a period of investigation began, this being accelerated by the advance in marine construction and the development of methods of navigation; but the discoveries for a long time were confined to the approachable coasts and to points inland which could be reached by water or by comparatively short land journeys.

Gradually, however, the work of adventurous explorers by land began to add a definite sum of knowledge about the interior of such hitherto unknown lands as Central Africa, portions of South America and the islands of the Pacific; but the results thus gained were attained only in the face of great hardship and suffering and attended with loss of life.

Before the introduction of railways the exploitation of the western portions of America was a most difficult problem, and the incentive offered by the discovery of gold in California was followed by weary marches across the plains under immense disadvantages.

A glance at the school maps of fifty years ago may be necessary to remind one of the immense spaces in the midst of Africa marked "unexplored regions"; the area comprising much of the prosperous West of the United States to-day was then included in the comprehensive title of the "Great American Desert."

Voyages up the river Amazon revealed the edges of tangled jungle, inaccessible to all except the wild animals and the scarcely less wild savages, and thus the severe limitations imposed by the lack of transport held back all but the most adventurous.

Even when formerly unknown areas were penetrated the difficulties of the journey and the limited carrying capacity of men or pack animals prevented the conduct of accurate surveying and mapping work, and very often the most meagre results followed upon exertions which actually reached points of great importance.

Until the present time the development of improved transport methods has aided but little in the work of interior exploration. Coasts are still made the points for the start of expeditions, as in the case of Arctic explorations, after which marches on foot, possibly accompanied by a few sledges or similar vehicles drawn by hardy animals, are made in much the same manner as obtained before the advent of the railway, the steamboat or the motor car.

These difficulties are due, in nearly all instances, to the impassable condition of the surface of the earth. The tropical jungle or the Arctic ice pack is so nearly impenetrable that it is only with the greatest difficulty that any rapid rate of progress can be made, while the opportunities for astronomical or geodetic observations are still less practicable. Even under such obstacles the surface of the earth is rapidly yielding to the persistent efforts of the explorer, and, with the aid of improved apparatus, it will soon be wholly explored and parcelled out for exploitation.

It is in this most desirable department of human effort that the development of aviation will certainly render important service. Until the machines for the navigation of the air are developed to an extent which will enable them to make journeys of several thousand miles without alighting for supplies, the full advantages of the command of the air for the exploration of the surface of the earth cannot be realized, since it will be necessary for the machines to be operated from bases of supply within their range of free travel. It is possible, however, even with the present limited radius of flying machines, that important service may be rendered to the explorer of difficult or impassable regions, especially if a systematic method of stations of supply be adopted.

One of the greatest difficulties which appears in the conduct of exploring parties upon the surface of the earth lies in the complete ignorance which exists as to the nature of the country immediately before the party in its progress. If it were possible to have some rough idea as to the extent of jungle, the course of rivers, the limitations of desert or mountain ranges, much time and effort would be conserved and a far greater amount of effective work could be done. Even if the aeroplane did nothing more than thus serve for scouting purposes it would render a great service; but when its further possibilities are considered, it will be seen how effectively it may even now be used in the work of opening up new regions. Until its radius of action, limited at present mainly by the fuel-carrying capacity, is extended beyond the present distance, it must naturally be used but little as the main apparatus for transport; but even with flights of about a hundred miles in extent a machine traveling through the air at a rate of forty miles an hour may precede and return to a main exploring party, bringing positive intelligence of the route which is to be traversed upon the surface. If the aspect of the ground is favourable, it would be practicable to send stores of fuel and other supplies ahead, and thus provide continuously a positive series of bases and remove almost wholly the uncertainties which are now so largely the causes of ill success.

One of the most valuable applications which may be made of the machine in the air lies in the possibilities of photographing the surface of the earth beneath and of providing data for accurate and rapid mapping of previously unexplored regions. Even in the case of rapid flights over new districts the camera enables the general character and topography of the land to be indicated, and as soon as a few conspicuous landmarks are definitely located the photographs in which they are included may be combined to form a fairly accurate scale map.

Certain obstacles which have always formed the great difficulties in the exploration of new districts appear in the form of mountain ranges and of densely wooded areas, and these must yield readily to investigation from above. The success which has attended the crossing of high mountains, both in Europe and America, reveals the extent to which this feature may be overcome. Flights over forests offer greater risks in the event of forced descent, but with improved machines and with experience in preliminary investigation there is reason to believe that the united work of surface and aerial explorers will be able to cover successfully any such portions of the earth.

The use of aerial apparatus for Arctic explorations will probably be more closely limited than at other parts of the earth, mainly because of the violent and erratic winds which are encountered as the poles are approached. The experiences of Andrée and of Wellman show that little success can be anticipated with gas-filled balloons, either of the rigid or the flexible type, and such attempts will doubtless be abandoned. It should be possible, however, to employ swift aeroplanes of moderate size and portable construction both to act as scouts and to aid in establishing advance bases of supplies to which surface parties may progress, and, by choosing periods when atmospheric conditions are favourable, such aerial advance guards should assist and guide the work of exploration, even under the difficult conditions which are known to exist.

An excellent example of the manner in which the uncertainties of inland exploration might be met by the aviator is seen in the long and laborious series of expeditions which were demanded before the facts concerning the sources of the Nile and the existence of the series of lakes in the interior of Africa were accurately known. The hardships undergone by such explorers as Burton, Speke, Grant, Baker and others were largely due to the impossibility of knowing the true nature of the problem before them or the magnitude and relations of the great bodies of water of which they could reach only a most limited portion.

If, instead of standing on the banks of such an inland sea as the Victoria Nyanza and being obliged to depend upon the unreliable or almost unintelligible statements of natives, the explorer had been able to rise a few thousand feet into the air, examining and photographing the entire area of water and banks, the problem would have been solved immediately and the record of the work made unfailingly and beyond controversy. In like manner the epoch-making journey of Stanley across the Dark Continent might have been relieved of many of its uncertainties if some available form of air scout could have formed a portion of his equipment.

It is evident that the use of the aeroplane for purposes of exploration will be accompanied with many difficulties, and will require some further degree of development beyond the present apparatus before any very general results can be expected. Naturally, the principal question which at first appears is the provision of sufficient fuel supply. The demands of existing machines for a special kind of liquid fuel, which must be transported from points of civilization to the route of exploration, certainly forms a handicap; but the same is true of the food supplies which have to be carried for nearly all expeditions. In this respect the aerial explorer will probably be obliged to imitate the practice of his Arctic associate and provide stores of fuel ahead, these being stocked by machines sent out for the purpose and especially equipped to carry extra fuel tanks, to be deposited at indicated points. It seems probable, however, that the demands of the entire industry of aviation will lead to the design of motors capable of using more than one kind of fuel and sufficiently flexible in this respect to be independent of connection with a special supply, at least for a short trip in case of emergency.

The machine for the use of the explorer should be capable of transport in parts, divided so as to be kept within the limits of burden carriers, when necessary; and it is probable that the first use of the aeroplane in exploration will be for short flights, almost wholly for observation purposes when the outlook is otherwise obscured, and in such instances the amount of fuel may be kept within transport limits and the aerial machine used principally for scouting.

Ultimately the final exploitation of the world will doubtless be conducted upon general and systematic methods, and the isolated efforts of individuals be superseded by the scientific invasion of unknown territory by parties working under government supervision or in connection with the plans of scientific associations. Such work would undoubtedly include a preliminary reconnoissance of the territory, followed by the establishment of bases of supplies, and it is in connection with such fully conceived and executed plans that the aeroplane would find its most effective opportunities.

A chain of isolated stations, erecting apparatus for radio-telegraphic communication, and equipped with supplies for sustenance and for motive power, might well be established wholly by aerial machines, and the spaces between them photographed and examined from above before any attempts were made to enter them upon the surface. Such a preliminary survey being established, the intermediate work could be done upon the surface in an intelligent and effective manner, connecting the bases without waste of time or misdirected effort. The difference between such a systematic advance and the former custom of pushing forward into an unknown wilderness represents all the difference between a thorough, efficient, scientific plan and an aimless and inefficient expenditure of effort and expense.

Apart from the possible applications of the aeroplane in the investigation of hitherto unexplored territory, it is possible that the machine in the air may be employed in the preliminary work connected with railway construction; for example, the general stretch of country through which a new line is to be constructed being examined, photographed and given a preliminary aerial survey before the precise route is selected. It is entirely probable that such a general view would enable the situation to be discussed in a clear and intelligent manner before any preliminary surface survey were started, and much expense, time and uncertainty would be saved.

The points above noted are only a few of the applications to exploration work to which the aeroplane is adapted, and many others will undoubtedly suggest themselves as occasion arises. The mere fact that the surface of any portion of the earth may be examined and recorded from above reveals the release which is obtained from surface obstructions, and the advantages which follow are obvious. In many respects the usefulness of aviation in exploration resembles its application to warfare, both in the capacity to reveal the field of operations and in the ability to carry the activity directly to the essential point under consideration. The warfare against the fortresses of Nature may thus be conducted with the same effectiveness as that against the opposition of a human enemy, and the ultimate result may be the same in both instances—the clearing away of all obstacles to civilization and the relegation of both kinds of warfare to the irrevocable past.

(To be Concluded.)

# EFFICIENCY IN FUEL COMBUSTION

By H. M. Wilson

EXTRACTS FROM AN ADDRESS DELIVERED BEFORE THE RAILWAY CLUB OF PITTSBURG

IN discussing the question of the possibilities of attaining higher efficiencies in the consumption and utilization of fuel, it will be advisable to commence with a consideration of the railway features of the problem.

The railroads of the United States represent the largest single group of coal consumers in the country. So vast is the extent to which coal is used on railways that it has been estimated by no less an authority than Prof. W. F. M. Goss that, in 1906, one-fifth of all the coal, anthracite and bituminous, mined in the United States was consumed in locomotives in that year. The gross amount of this coal consumption was not less than 90,000,000 tons, used in the operation of about 51,000 locomotives. Another estimate indicates that in the same year the coal bill of the railways of the United States aggregated 170 million dollars.

Two years later, in 1908, statistical reports show a coal production in the United States of more than 410,000,000 tons. The very carefully prepared report of the Federal Conservation Commission estimated that nearly an equal amount of coal was lost to future use in the getting of this coal. This waste was the result of prevalent methods of mining, whereby only the highest grade of coal is extracted, that of inferior grade being left in the ground or otherwise wasted, because not of marketable quality.

The same commission reported an enormous loss of fuel value in the conversion of the latent energy of the coal into work, as power or light. Comparing the opinions of a number of authorities on fuel combustion, it has been estimated that, in the average steam-power plant, about 6 per cent. of the fuel energy does useful work, while less than 1 per cent. is converted into the light emitted from the electric lamp, more than 99 per cent. being lost. In the case of power production through steam with some of the most modern insulations in large units, as used in central power stations for generating electricity, as much as 10 per cent. of useful work may be produced. These losses occur in starting the fires, in vaporizing the moisture in the coal, in exhaust steam, in radiation from boiler and pipes, in gases discharged through the stac, and in ashes, while another large portion is lost in the engine through friction, inertia, etc.

In reporting for the Geological Survey on investigations concerning the use of fuel in locomotive practice, Professor Goss stated that, in the average locomotive furnace, 20 per cent. of the total fuel supplied to the locomotives performs no function in moving the train forward. In fact, only about 40,000,000 out of 90,000,000 tons consumed in locomotives in 1906 represented heat transmitted from the furnaces to water to be vaporized. Adding to this the losses by radiation, in transmitting the steam power through the engine to the axles, adhesion to the rails, etc., it is estimated that, of the latent heat value in the coal, probably not over 5 per cent. does useful work in moving the trains forward, the remaining 95 per cent. being wasted.

While we are not justified in assuming that any large proportion of the latent fuel energy now lost in power production will be saved to useful work, I believe that we are warranted in bringing the above facts clearly to the attention of the public through the medium of engineers and operating officers, in the hope that thereby fuel users may be induced to give more careful consideration to possible means of more economic fuel combustion.

A quarter of a century ago there was not a producer-gas plant in operation in the United States. To-day there are estimated to be 500 such plants, some of unit capacity of 5,000 or 6,000 horse-power, and producing, in all, nearly 120,000 horse-power. It is well known that producer gas can be manufactured from coals of such low grade as to be valueless for steaming purposes, thus saving that much higher grade coal for other uses. It is also well known that, on the average, the producer-gas plant to-day converts into useful work from 10 per cent. to 16 per cent. of the latent energy of the fuel, the average being more than 13 per cent. Where such means of power production can be economically substituted for steaming plants, an average saving in fuel value of 5 per cent to 8 per cent. may be effected. Here, again, the figures run into the millions, not to mention the extension of the probable life of the existing fuel resources of the country.

Much of the coal discarded to the culm bank in the anthracite regions has been recently proved to be a valuable source of fuel, not only in the gas producer but for use in the boiler furnace, by conversion into hard nodules called briquettes. By briquetting the waste anthracite culm and the slack left at bituminous mines a further source of fuel saving has been developed. So, also, within half a generation further enormous waste through the fuel gases of the blast furnace, the coking oven, and similar appliances have been proven unnecessary and avoidable.

Finally, whereas until recently it was customary in American mining to leave an average of 50 per cent. of available coal in the ground, a loss to all future time, and to discard all other valuable coal prior to the more general introduction of washing and sorting methods as now practiced, it is conceivable that, with better practice, as evidenced in Europe, and with more favourable commercial and transportation conditions, these mine wastes may be reduced to 25 per cent. or less. This would represent a saving to the future of one-quarter of the present annual production of 500,000,000 tons.

For the above reasons the Congress of the United States, and, through it, the Secretary of the Interior, have directed that the recently created Bureau of Mines shall devote its first energies to an investigation of the problems connected with the mining, preparation, and marketing of coal and its conversion to commercial use. Beginning under the Geological Survey in 1904, fuel investigations were undertaken in a small educational way at the Louisiana Purchase Exposition. Since that time commercial steaming tests have been made by the Government on nearly 500 different coals from the various mining regions of the United States. Nearly two hundred producer-gas tests have been made upon an almost equally large variety of coals in both up-draft and down-draft gas producers. Fifty tests have been made of coals from different parts of the United States to determine their coking value; and, whereas many of these coals were formerly not believed to be coking coals, methods of washing, mixing and firing them have been developed which show some to be valuable for coking purposes. In like manner, commercial tests have been made on carload lots of high-grade coal, on slack, and on culm and lignite, to determine the best methods of converting them into briquettes and ascertain the efficiency of these when burned by different means in stationary and locomotive furnaces and domestic heating and cooking stoves.

With the results of these preliminary investigations before them, and with the removal of the uncertainty surrounding the work of the Geological Survey, due to the hand-to-mouth method of making annual appropriations, it is now possible for the officers of the Bureau of Mines to plan broadly and deeply for the future.

This investigative fuel-testing work by the Federal Government is not to be confused with that variety of testing conducted by commercial institutions, railways and power plants. These have as their primary object the testing or development of the machine. The investigations of the Federal Government have, as their primary object, the better utilization of the fuel resources of the country. The Bureau of Mines tests are, therefore, not competitive or investigative tests of the various makes of power producer, but they have in view the ascertainment of the best existing type of commercial appliances in which to burn with highest efficiency each separate variety of fuel. They are also planned with a view to learning something of the fundamental principles underlying fuel combustion in various appliances, in the hope that thereby inventors and manufacturers may develop improvements in them.

The Bureau of Mines has another function to perform in connection with its fuel tests which has led to much misunderstanding of its purposes and some unwarranted criticism. Used as a testing laboratory by the several hundred purchasing officers charged with the procurement of fuel for the power plants in hundreds of public buildings scattered from Maine to California, in the power plants of the Isthmian Canal Commission, the steamships of the Panama Railway, the heating plants of the various military posts and Indian agencies, the Bureau of Mines is charged with the duty of protecting the Government to the extent of ascertaining that the quality of coal furnished by contractors is the highest procurable under the specifications. Of more than 400,000 tons of coal shipped annually to the Isthmus of Panama and 100,000 tons consumed in Panama Railway steamships, specifications calling for an unusually high-grade fuel have been adopted by the Government purchasing officers, as would be done by those of any commercial institution which aimed at economic business management. It would be unprofitable to transport from the mines to the Isthmus the vast tonnage represented in an unnecessarily high ash or moisture content. On the other hand, the Bureau of Mines has been instrumental, in the cases of many public buildings throughout the United States and in the forty-odd buildings in Washington, in showing how, bv comparatively minor changes in existing equipment, or replacement thereof, or different methods of manipulation therein, it is possible to burn advantageously lower-grade coal, bituminous coal or buckwheat anthracite, in place of high-grade and expensive steaming coal or furnace anthracite previously in use. In one public building in Washington alone it is estimated that a saving of $15,000 was made by change of furnace equipment, whereby buckwheat was substituted for furnace anthracite. In buildings there and elsewhere the use of bituminous coal has recently been introduced through the agency of this Bureau, thus encouraging, so far as possible, the use by the Government of the cheaper low-grade and comparatively waste fuels in place of the more expensive and scarce high-grade fuels.

It is well known, perhaps, that

when coal is contracted for and sold under some trade name such method of sale gives little opportunity for the purchaser to determine an inferior delivery in case the vendor is short of the coal contracted for. Moreover, the purchaser would have little resource in the courts, especially if much of the coal has been consumed. The Bureau of Mines, and its predecessor, the Geological Survey, have consistently advocated the purchase of coal on a specification which fixed the heat value of the fuel offered. Such an arrangement is eminently fair both to seller and purchaser; the chemical analysis determines the number of heat units, or British thermal units, in the average sample, and according as the delivery is above or below premiums or deductions are made in settlement. No question need be raised as to the rejection of the delivery, for the purchaser will pay a less price for an inferior quality. In other words, he will get what he pays for and the vendor will be paid for what he sells.

To-day the United States Government, which, through its many agents, is the largest single purchaser of coal in America, buying annually an amount estimated materially in excess of 6,000,000 tons, is procuring 3,000,000 tons of this on specifications fixing the number of British thermal units. The remainder of its fuel purchases, chiefly those for the navy, have been practically reduced to an equivalent basis through the tests and mine data furnished the navy purchasing officers. Nevertheless, this feature of the work of the Bureau of Mines, which, as previously stated, has brought some criticism of its apparent encouragement of the use of only high-grade coal, is the least of that Bureau's operations in connection with fuel investigations.

Attention has been called to the many hundred steaming investigations made by the Bureau of Mines. These tests have been made on horizontal return tubular boilers and on water-tube boilers of standard make, used in the daily power production at the Testing Station in Pittsburg. They have covered such a wide range of fuels that they may be characterized as a combustion survey of the coal of the United States. These coals are burned in furnaces in which the baffling is changed from time to time. They are hand-fired or mechanically stoked, with underfeed, over-feed or chain-grate stokers. The draft may be natural, forced or induced, or a combination of the latter. It has thus been possible to determine, in a preliminary way, what type of furnaces, how baffled, how fired, how stoked, and with what draft, each coal should be burned in order that it may produce the highest efficiency and emit the least smoke. Similar investigations on some hundred coal purchases in different parts of the United States for use at army posts have been conducted on three types and sizes of heating boilers—a small one for heating a residence building or officers' quarters, a larger one for heating a medium-sized hospital or medical hall, and a good-sized boiler for heating a large barrack building. In the latter connection a series of tests is now in progress to ascertain the most efficient and most smokeless method of using the different coals in a horizontal return, tubular hand-fired boiler of medium capacity—50 horse-power.

In each test a mining engineer of the Bureau samples the coal as mined and as loaded in the cars. Samples are taken when unloaded at the Testing Station and as fired. A bulletin is in course of preparation setting forth the result of the approximate analyses, calorimetric determinations and ultimate analyses of nearly 5,000 mine samples, of which the origin and history are authenticated. With this information, it is possible for the Government representatives—and it should be for those of railway and commercial institutions—to predict the character of the coal which can be furnished them from any mine in the United States. Through the medium of the ultimate analyses it has been possible to detect that coal specified by the name of a colliery or coal field—for instance, as Pocahontas No. 3—did not come from that seam, but from some other seam carrying a less high-grade coal, though drawn from the same shaft and through the same tipple.

In the course of these tests feedwater is weighed and analyzed, clinker and ash are weighed and analyzed, and fuel analyses and temperature measurements in the furnaces and in the flues are taken. These data furnish an invaluable index to the best method of utilizing each coal and for pointing the way for future investigations along these lines.

The gas producer investigations, the briquetting and coking investigations, have been accompanied by similar care in fuel sampling and in chemical and physical analyses and measurements.

In the tests heretofore run no difficulty has been experienced in making runs of a week duration on any fuel, including the most volatile bituminous coal, lignite and peat. Comparisons of the several hundred tests run on coals from different parts of the country in the steam boiler and the gas producer are most interesting. The gas producer operated in the best way with the West Virginia coal produced 3.3 times as much efficiency as did the steam boiler of the best type, operated in the best way in test practice. The lowest grade of lignite developed, in the gas producer, about the same efficiency as did the best steaming coal under the boiler.

The preliminary briquetting tests have proven the value of this manufactured product as a substitute for run-of-mine coal under certain conditions. The coal is ground and mixed with a small percentage of binder, usually 5 or 6 per cent., of pitch. It is then heated and briquetted under a pressure of one or two thousand pounds per square inch. These coal briquettes burn from the outside, giving off the volatile matter slowly and coking as the combustion proceeds until the entire briquette is consumed. They burn much as does furnace anthracite. A number of carloads of lignite each, from Texas, Colorado and Dakota, have been successfully briquetted at the Pittsburg Testing Station of the Bureau of Mines. For this purpose the lignite is disintegrated, then dried, to free it of excessive moisture, and is then briquetted under great pressure—about 20,000 pounds per square inch—the resulting briquettes being as firm and hard as anthracite. They are especially well adapted for combustion in locomotives or in house-heating furnaces and cooking ranges. This fuel, like slack coal, may be had at the mines at about $1 per ton. Adding $1.50 for manufacture and binder, a product is obtained at $2.50 per ton at the mine, which compares favourably with high-grade bituminous or anthracite coal. Since the Government and the railways own some millions of acres of lignite in the Western States, this will undoubtedly be an economical source of coal supply when its manufacture on a commercial scale is perfected. A few years ago a coal famine occurred in mid-winter in North Dakota. This was due, in a large measure, to the reliance of that region on the slack coals of neighbouring States, which could not be carried long in storage and required daily deliveries. Heavy snow drifts impeded transportation, and the resulting suffering ensued. Briquetted lignite can be carried in storage throughout the winter months.

# THE ORGANIZATION OF COMFORT AT SEA

### By Alwyn Waters

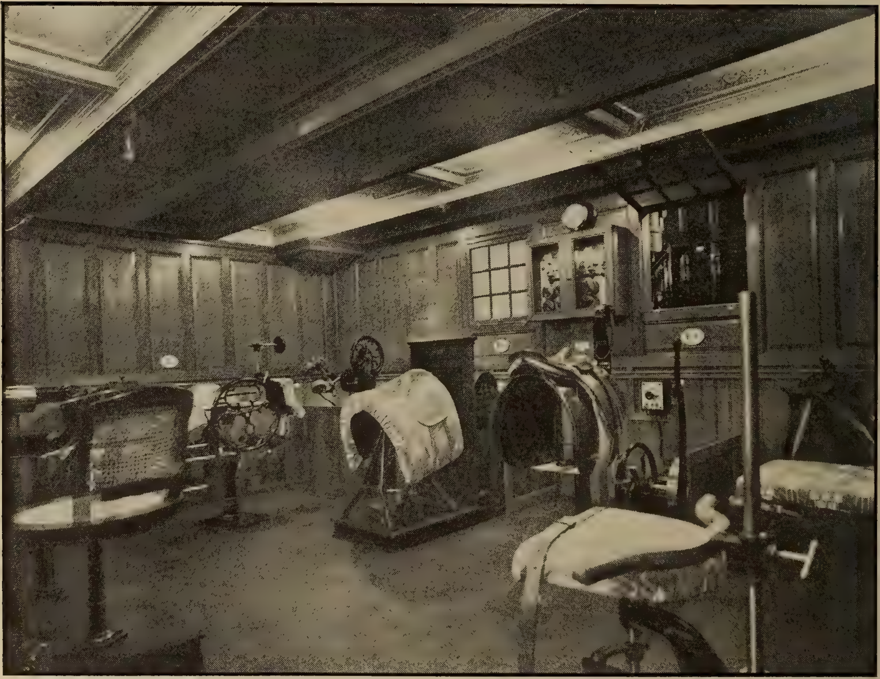
IN former days the principal consideration in ocean transport lay in the conduct of the navigation of the vessel, and while the passengers were cared for as well as ordinary conditions would permit, this feature formed a secondary element in the undertaking. Even at the present time instances are found in which the operation of the ship, considered as such, seems to occupy the chief attention of those in charge. With the development of the great liners, however, it is being understood that an ocean steamship is really a great floating hotel, and that upon the conduct and administration of all the elements which go to make up the ease and comfort of the passengers the commercial success of the business may depend.

No more completely organized community may be found in the world than aboard the great modern ocean steamers. When two or three thousand people are obliged to live within the boundaries of one of these steel hulls every detail of their life must be carefully systemized. As the result of long experience it is now possible to gather travelers from every walk in life and carry them across the seas without one of them foregoing the comforts they may be accustomed to ashore. Here is an immensely complicated problem, which is rendered more difficult by the necessarily restricted boundaries of even the great ocean leviathans.

Before the tourists set sail they must, of course, consider the question of banking, which must be carried on probably in many strange cities far from home. It is only a few years since the traveler could depend upon but one medium—gold—to be honored in all countries. This he carried in the proverbial leather belt against loss of all kinds. This situation was partially improved by the use of letters of credit. The improved manner of carrying money to all parts of the world is admirably illustrated in a remarkable incident which occurred recently in New York. A wealthy tourist was so unfortunate as to lose his pocketbook in New York the day before sailing. It may have been a robbery; in any event, the steamship tickets for himself and daughter and $1,075 were gone. The tourist had taken the common-sense precaution of purchasing travelers' checks to the value of $1,000, which are honored the world over at their face value and yet are so safe that they are of no use to any but the owner. The pocketbook in question was found and the $75 removed, when it was dropped in a Broadway letter box. In due course it reached the post office early the next morning, when the steamship company was notified, and, by quick work, the tickets and the $1,000 were handed to the traveler before the steamer sailed. The travelers' checks would be equally as safe on the other side of the world.

When the ocean liner arrives in port the most expeditious work is required in the few hours she is at the dock to prepare her for her next trip. To assure the comfort of the tourists, the vessel must be thoroughly cleaned inside and out. A gang of men scrape and newly paint the funnels, the hulls, and all the great expanse of woodwork. Other workmen take up all the carpets

GARDEN ON THE STEAMSHIP KAISERIN AUGUSTE VICTORIA



GYMNASIUM ON THE STEAMSHIP AMERIKA

throughout the vessel, clean them, and, after scrubbing the floors, all the tables are repolished, the chairs regilded and stained, and the metal work polished until it glistens. There are some 30,000 pieces of linen on a single ship to be counted, sorted and laundered. In the steward's department there are 15,000 pieces of silverware, 25,000 pieces of glassware and 60,000 dishes, plates, cups, saucers, etc., to be gone over.

The modern ship's laundry might well serve as a model on land. A curious problem has been met in the case of the S. S. *Cleveland,* of the Hamburg-American Line, which carries a party of 500 tourists around the world. The laundry, equipped with all the newest labour-saving ma-

THE SERVING ROOM ON AN OCEAN LINER

TEA-ROOM ON ONE OF THE HAMBURG-AMERICAN BIG OCEAN LINERS

chinery, is operated by a special staff of eighteen experienced laundrymen. All the laundry work of the 500 tourists is carried on about as expeditiously as on shore.

Every refinement of service which may be employed in the best hotels on shore is insured to this densely populated steamer. That everyone may have his daily bath calls for very careful organization in this department. A small regiment of bath stewards is employed in this department alone, and, in addition to the ordinary bath, there are Turkish baths, electric-light baths, and masseurs.

The provisioning of an ocean liner calls for very careful organization of the steward's department. The menu is extremely elaborate throughout the longest voyage. Some time ago a West Indian steamer, outward-bound, chanced to run on a reef, where she was held for a month. The passengers meanwhile were living on board. On the last day of their enforced imprisonment ice cream was served for dessert, which had been taken on board before sailing. A great ocean liner carrying 1,500 passengers carries, first of all, some 425 tons of fresh water, 6,000 gallons of wine, beer, etc. Vegetables to the amount of 2,500 pounds and some 1,400 pounds of fruit must also be taken on board. The larder must also contain 3,500 pounds of meat, 5,000 pounds of poultry, 3,000 pounds of fish, some 20,000 dozen eggs, 7,000 pounds of butter, 1,800 gallons of milk. This vast supply is only intended for a six-day trip.

A great army of employees must be carefully trained for this complicated work. The Hamburg-American Line, for instance, employs some 33,000 men, as completely organized as any regular army. A complete system of insurance and benefits has been organized. At the end of a life-service the men are pensioned.

# LONGLEAF PINE—A GREAT STRUCTURAL TIMBER

By **W. M. Hall** and **H. Maxwell**

One of the important services rendered to the engineer by the United States Department of Agriculture appears in the various publications which furnish recent and reliable information concerning certain materials of construction. A recent bulletin of the Forest Service, devoted to the subject of the commercial woods of the United States, and specifically to the pines, contains a most valuable examination of these timbers for structural purposes, and the following extract, covering the important and invaluable longleaf pine, will be found of much interest and value.—THE EDITOR.

THE physical properties of longleaf pine, upon which its value to the engineer and builder depends, are as follows:

Weight of dry wood.—43.6 pounds per cubic foot (Sargent).

Specific gravity.—0.70 (Sargent).

Ash.—0.25 per cent. dry weight of wood (Sargent).

Fuel value.—94 per cent. that of white oak (Sargent).

Breaking strength (modulus of rupture).—16,100 pounds per square inch (Sargent).

Factor of stiffness (modulus of elasticity).—2,118,000 pounds per square inch (Sargent).

Character and qualities.—Heavy, hard, very strong; tough; grain fine, even, straight; compact, annual rings narrow, especially in young and old growth, summerwood broad, occupying fully half the width of the annual growth, proportion of heartwood large; very resinous, resin passages numerous and large; medullary rays numerous, conspicuous; color light red or brown, the thin sapwood light yellow; durable in contact with the soil.

Growth.—Height, 55 to 100 feet; diameter, 1½ to 3 feet.

The commercial range of longleaf pine lies in Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina and Texas. Few woods have a greater number of names in different localities than this tree. Among them are longleaved pine, Southern pine, yellow pine, turpentine pine, rosemary pine, brown pine, hard pine, Georgia pine, fat pine, Southern yellow pine, Southern hard pine, Southern heart pine, Southern pitch pine, heart pine, pitch pine, longleaved pitch pine, longstraw pine, North Carolina pitch pine, Georgia yellow pine, Georgia heart pine, Florida yellow pine, Florida pine, Florida longleaved pine, Texas yellow pine, Texas longleaved pine.

The total stand of the timber pines of the South is estimated by the Bureau of Corporations at 384 billion feet.[1] Of this amount, 232 billion feet is of longleaf and 152 billion feet of shortleaf and loblolly pine. The figures for the longleaf include whatever there is of Cuban pine, as the two species were not distinguished by the Bureau of Corporations. It has been roughly calculated that, at the present rate of cutting, the supply of the Southern pines will last from twenty to thirty years; and since the rate of lumbering is relatively about the same for all regions where the different species grow, it is assumed that failure of supply will come to the four species at about the same time. Much more of longleaf and loblolly remain than of shortleaf and Cuban.

Longleaf pine in many sections of the South reproduces itself with vigor, but because of its slow growth while young it fails to establish itself as well as the white pine of New England and the yellow pine of the

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[1] Report of the Commissioner of Corporations on The Lumber Industry, February, 1911.

Far West. Fire is the one great enemy over all of its range, and destroys seedlings in vast numbers, though larger trees resist well where they have not been boxed for turpentine. The prospect that new growth will take the place of the forests now going down before the lumbermen is not encouraging, more because of slow growth than of difficulties in reproduction. The annual drain upon Southern pine forests to supply the demand for lumber and the fact that fires interfere so greatly with reproduction must lessen the remaining supply very rapidly.

The early explorers and colonists encountered the longleaf pine practically all the way from the Chesapeake Bay to Texas, with the exception of Southern Florida. As the country began to be settled immediate demand upon the forests was made for building material needed in an agricultural region. A hundred years ago it was claimed that 75 per cent. of the lumber in residences in the longleaf-pine region was of this wood. In many cases the entire house, so far as it was made of wood, was of this material. The most frequent exception was the roof, where cypress was commonly employed, with occasional roofs of red cedar and Southern white cedar. In some cases shingles of pine supplied roof material also. Barns, sheds, stables and all farm buildings drew enormous supplies from the neighboring longleaf-pine forests, and the inclosing of fields and plantations added to the demand. Pickets for garden and yard fences were sawed from the wood, and post and plank fences were sometimes constructed wholly of it. When pine posts were used it was customary to select the dead timber that had become "fat," a term applied to wood surcharged with resin. It was claimed that sometimes timber left standing after it was dead would double in weight merely from the accumulation of resin in it; but figures showing an increase in weight so large as that should be accepted with caution. It is certain, however, that the fat pine posts gave long service, which led to extensive use of that class of timber. Rail fences were common in early plantation days in the South, and the longleaf pine was split for rails and lasted well.

One of the earliest demands upon the longleaf pine was for bridge material. Public highways and private roads depended largely, sometimes almost wholly, upon it when streams and ravines were to be crossed.

Longleaf pine contributed to the machinery used on Southern plantations, though in early times the use of farm machinery was more limited than at present. A large part of the work was done by hand labour; but wagons and carts were indispensable, and the beds were oftener made of pine than of any other wood.

The old Ramage printing press, made a century and a half ago and now in the National Museum at Washington, D. C., is largely of longleaf pine.

The exportation of building material from the longleaf-pine region began very early, and the lumber for that purpose was sent in small sailing vessels to Cuba and the eastern coast of Mexico and Central America. It was preferred in many cases to the native timber, because it was comparatively free from attack by ants, which in tropical countries frequently destroy houses and eat away bridge timbers.

The Southern pines attained to considerable importance in the export trade soon after the Revolution, and at the beginning of the Civil War were going in quantity to English markets. The closing of the Southern ports early in the war left some of the operators and contractors with timbers on hand which they had expected to send abroad. A large number of rafts were caught in the Altamaha River by the blockade, and these the owners towed to places of concealment in estuaries and bayous, where they remained unmolested until the termination of the war.

It was about that time that the longleaf pine began to displace in English shipyards the pine from Memel (a port on the Baltic Sea).[1] It found place in heavy construction on land, as well as in shipbuilding. It was stronger than the Memel pine and could be had in longer pieces, up to 45, 50 and even 60 feet in length, and 14 inches square, free from sap. A favorite use for such timbers in England was for wharves and harbour works, as well as for supports for roofs and galleries in churches and other large buildings. Pavement was made of it for shop floors, each block being made of four pieces fastened together with dowels. The timber in England has given twenty years' service in damp and unfavourable places, but has not proved so satisfactory in South Africa, particularly near the Cape of Good Hope and near rivers, where the climate is alternately dry and damp.

In the export of lumber at the present time from the United States to foreign countries the Southern yellow pines are not listed separately, and it is not practicable to determine what part of the total lumber exports they supply. It is believed, however, that a billion and a half feet of these pines go yearly to foreign countries, the most of it longleaf. This places it above Douglas fir, its next nearest competitor, as an export wood. The pine is sent in large quantities to Mexico, the West Indies, Central America, the Panama Canal zone, South America, and to Great Britain and the Continent of Europe, as well as to many other parts of the world.

From earliest times the Southern shipyards drew supplies from longleaf-pine forests. The timber was sent to Northern yards also, and its value for masts was quickly recognized after the Southern forests became known. It is heavier than white pine, and to some extent its weight was objectionable, but its other qualities were so much in its favour that it speedily won its way. Before supplies began to be drawn from the South the Riga and Danzig pines from Northern Europe furnished masts for a majority of European vessels, but in a few decades after commerce with the South began the longleaf pine had distanced its competitors in that trade. For the largest masts, however, it could not compete with the New England white pine. Spars, yards and other timbers employed in ship rigging were bountifully supplied by longleaf pine, and large quantities of sawed planks were used.

The first war vessels built by the United States Government, beginning about 1797, used longleaf pine to some extent, though the frames and other parts subjected to shock and strain were of live oak. The six vessels forming the first Federal Navy had the Southern pine in them. The *Constitution,* launched at Boston in 1797, and which in its long and eventful history captured sixteen ships, still rides at anchor at Boston; but it can scarcely be called the same vessel that won the victories nearly a century ago, for piece by piece it has been rebuilt until practically all the old wood has been replaced by new. However, the figurehead that ornamented the prow of the ship when it first sailed remains, though it shows the weathering effect of over 100 years of sunshine and storm. It is of longleaf pine—a wood which, in this instance, has outlasted all that were associated with it in the building of the ship.

Boat builders in all Eastern and Southern yards of the United States use longleaf pine. It serves in nearly every part of boat frames and planking, in large craft as well as in small.

Only one other timber in the United States at present stands on an equal footing with longleaf pine in heavy construction, such as beams, girders, sills, sleepers, joists, trusses, rafters, columns and heavy floors and planking. That wood is Douglas fir of the Pacific Coast. It has been said that lumber dealers do not always distinguish between longleaf, shortleaf, loblolly and Cuban pines, but longleaf is the most important of the group. Its strength, stiffness, freedom from defects, and its lasting properties fit it for many places in heavy construction. The demand for pieces of unusual size is met, to a large extent, by Southern mills, which cut this species.

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[1] Timber, J. R. Baterden, London, 1908.

In 1907 the railroads of the United States purchased 34,215,000 ties of Southern pine. In 1908, largely due to the financial depression, the number fell off to 21,530,000, and decreased to 21,385,000 in 1909. It is impossible to tell what proportion was of longleaf, but it is known that it was large. The cutting of ties in the Southern pine forests has caused much waste. It has been estimated that not less than 70 feet of lumber are sacrificed to procure one tie, which, at most, contains not above 50 feet, and generally nearer 40. Ties are usually cut from young trees.

Builders of railroad bridges and trestles draw a large part of their heavy timbers from the longleaf forests. The wood is pre-eminently fitted for that use. It may be had in long pieces, free from serious defects, and posesses great strength and stiffness. In addition to that, it has enduring qualities which add much to its value.

It is extensively employed in car building—to some extent for passenger cars, but chiefly for freight. It is used for siding, lining, roofing, flooring, beams and frames. The timber's elasticity is its chief value in car building. Sticks free from defects are often demanded 10 inches square and from 36 to 42 feet long. Elasticity adds value to the crosstie also, for the wood must yield under weight and strain and quickly recover its former shape and position.

Southern pine has always had a place as interior finish in the South, but until comparatively recent years it was not favoured for fine work, but was chiefly confined to kitchens, pantries, back stairways and similar places. It was nearly always finished in natural colours, if finished at all; but when it was discovered that it took stains well it quickly rose to importance and has attained wide use. In the best construction, however, it has never reached a footing equal to oak, chestnut and birch. Immense quantities are made into flooring, and manufacturers of window and door frames and of sash and doors draw supplies of raw material liberally from that source. It finds place as finish for kitchens, halls, libraries and sleeping apartments. It is made into stairs, railing, molding, spindles, balusters and newel posts. Church and schoolhouse finish is made of it, and it has extensive use in the manufacture of furniture, cabinets and wardrobes. Various parts of machines are made of it in Southern mills, shops and factories, and the makers of farm machinery and appliances use it in many ways where formerly ash and oak were the only woods employed. In a large part of the country it is so universally used that there are but few places of importance that it does not fill.

Formerly it was customary for large contractors to specify that the timbers supplied should not be "bled," referring to the practice of extracting crude turpentine from living trees. It was supposed that the wood from such timber was inferior. Railroad companies frequently excluded such stock. Tests by the Forest Service some years ago showed that "bled" timber is not reduced in strength. The bleeding does greatly increase the amount of resin in the butt of the tree, and this is sometimes found objectionable. Also, the turpentining of the tree does reduce, to some extent, the quantity of first-class lumber which can be obtained.

The extensive use of wooden paving blocks, treated with preservatives to retard decay, covers a period of only a few years in this country, and longleaf pine has been the principal wood so used. Before the necessity for wood preservation and the methods of bringing it about were well understood, a large amount of wood pavement was laid in many cities of this country. Of this untreated wood pavement there was probably more Northern white cedar from the Lake States than of all other woods combined. The unsatisfactory use which such pavement gave led to its abandonment, and treated woods came in. The hard Southern pines, particularly the longleaf pine, were favored by many cities, and in 1909 more than a million square yards of this timber received treatment for use as paving blocks. Some use of it was made long before. Between 1860 and 1870 Brooklyn laid pavement of this wood previously dipped in coal tar. The average life of the blocks under traffic in that city was about six years.

Treated paving blocks of the Southern pines have replaced other materials to a considerable extent in many American cities and have gained some foothold in European cities. In the United States they have been laid in New York, Boston, Baltimore, Washington, Indianapolis, Chicago, Minneapolis, Duluth and in other cities. In addition, much wooden pavement has been laid between car tracks in cities, on wharves and landings, in coal yards, on bridges, in warehouses, foundries, shops, roundhouses, breweries, cellars, bottling works, and in many situations where heavy wear must be sustained and liability to decay resisted.

Longleaf pine is largely employed in railroad water tanks, towers, for windmills and receptacles for liquids in factories and mills. The tank itself and the stand on which it is placed are frequently of this wood, but in tank building longleaf pine is not as extensively used as cypress.

Trunk makers use many woods in their business, and longleaf pine has a prominent place, though its weight places it at a disadvantage when competing with others.

Excelsior cutters drew upon it for supplies, but it has no superiority for that use over many other woods.

A small quantity of longleaf pine is manufactured into pulp, the material used, for the most part, being sawmill waste. At certain plants in the South it appears that the process of making paper from sawmill waste is becoming established on a successful basis. If so, it means the extension of the pulp industry to the Southern States, with longleaf pine as the raw material.

The long, clear timbers cut from this pine are well adapted to the manufacture of wooden pumps, and a considerable amount is so used.

Elevator builders draw supplies from the longleaf lumber yards of the South, where clear stock and exceptional lengths may be had.

Longleaf pine has held an important place in the production of naval stores since the development of the country began. A century ago Michaux listed the longleaf pine's products as "wood turpentine, scrapings, spirits of turpentine, rosin, tar and pitch." He described turpentine as the raw resin that exuded from the wounds in the trees; scrapings, as the dried substance that adhered to the wounded surface; spirits of turpentine, as the product passing over in distillation of turpentine; rosin, the residuum of distillation; tar, the substance obtained by the destructive distillation of pine wood; and pitch, the product obtained by boiling the tar. Longleaf pine has been, and still is, nearly the entire source of these products.

Immediately after settlements began on the Atlantic coast Great Britain encouraged the development of the naval-stores industry. Her ships demanded large quantities, and the supply then came from the Baltic Provinces and from Russia. Monopoly, it was claimed, raised the price, and in time of war there was danger that supplies would be cut off. For that reason it was desirable that America should become a producer of the commodities so necessary to the maintenance of England's position upon the seas. The colonists in New England had scarcely landed before they were encouraged to look into the possibility of developing the naval-stores industry. The same was true in Virginia. Within fifteen years after the feeble settlement had planted itself at Jamestown a report was made on the possibilities of developing the tar and pitch industries in the region on and near the coast of Virginia.[1] The report was unfavourable, for the reason, as it was set forth, that pines were too much dispersed to make the manufacture of pitch and tar profitable. This report has been construed as evidence that pine was much scarcer in the original forests of tidewater Virginia than in the secondary forests which grew afterwards.[2] The prevailing pine in that region is loblolly, which readily takes possession of abandoned fields.

The manufacture of naval stores began on a small scale in the longleaf-pine region and grew gradually. Statistics showing the progress of the industry are fragmentary. In 1704 the shipments of tar to England from the Carolinas amounted to 400 barrels. One hundred years later the annual output of the South was 77,827 barrels. How much of this was tar and how much was rosin and other products is not shown. The shipments went to Northern States and to Europe. In the North the article was employed, to a considerable extent, by soap manufacturers. In the same year (1804) 19,526 gallons of spirits of turpentine were shipped from North Carolina. In later years petroleum was substituted for spirits of turpentine in many arts and industries.

The value of the naval stores produced in the United States in 1908, chiefly from longleaf pine, was $21,895,950. Florida was the largest producer. At one time North Carolina stood first, then the first place went to Georgia, and later to Florida. The centre of the industry shifted from region to region where pine was most convenient and abundant. In early years the turpentine operators destroyed forests for naval stores alone and made no use of the wood. They boxed the trees—that is, cut deep notches in the base of the trunk—and collected resin year by year for a time. When the trees could produce no longer they were abandoned to fire and storms. The weakened trunks were broken and fire completed the ruin. At the present time less wasteful methods are employed. The lumber is valuable and less frequently left to burn or decay. Improved methods have been found for extracting the resin. Cups are taking the place of the deep boxing that once was everywhere in use. Under the new system of working the product is better and more abundant, and the trees sustain less injury. In 1908 about 14 per cent. of the turpentine was produced by the cup method. The improved processes continue to grow at a rapid rate.

A considerable portion of the longleaf pine forests of Northern Alabama was denuded years ago to supply charcoal for iron furnaces in that region. A similar use of the wood has been made wherever sufficient market has existed for charcoal. In some localities refuse wood only is taken, while the rest goes to the lumber operators.

Several billion feet of yellow pine pass through dry kilns yearly, and it has been estimated that for every

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[1] Neill's Virginia Co., of London, page 283, report made in 1622.

[2] An inference that pine was plentiful near the sea, but not in the interior, has been drawn from a paragraph in John Oldmaxon's British Empire in America, edited by Hermann Moll, London, 1708. In accounting for the failure of grape culture in Virginia, he said: "Fir and pine trees, with which the country abounds, are noxious to the vine; and the experiments that have been made were in the lowlands, subject to the pine, and near the malignant influence of the salt water." (Vol. 1, page 306.) Two hundred years ago, and about the same time that Oldmaxon wrote, John Lawson traversed the uplands of North Carolina for a distance of 125 miles and noted particularly that he saw no pine trees, but when he had proceeded eastward into what he called the "lowestmost parts" he encountered an abundance of pine.

1,000 feet entering the kiln a gallon of turpentine evaporates and is wasted, or an equivalent of three or four million gallons annually. It is believed that the expulsion of nearly all the turpentine from the wood is practicable, and that little or none of it need be wasted, while the quality of the lumber would be improved. Turpentine and pine oil are now being obtained from longleaf pine mill waste at a number of Southern mills by steam distillation. At certain mills the shredded material is afterwards used for manufacturing paper. It is estimated that the waste of longleaf pine is sufficient to supply a quantity of turpentine equal to that now produced in the naval-stores industry. A large number of plants are running on longleaf pine stumps and "fat" logs by the destructive distillation process. The chief products of this process are turpentine, pine oil, pyroligneous acid, charcoal and tar. In certain extraction processes the turpentine, pine oil and rosin are obtained. The obtaining of such products from longleaf mill waste appears to be on the threshold of rapid increase.

The long needles of this pine have been used for various purposes. If distilled green, an oil of balsamic odour is obtained, closely resembling spirits of turpentine. By the distillation of the wood spirits of turpentine may be obtained, the yield running from 1 to 10 gallons per cord. Pine wood is made from pine needles by boiling them in a strong solution of alkali. The resulting fibre is cleaned, carded and made into fabrics or used in upholstering.

One of the materials used in manufacturing lilac perfume is terpineol—made from turpentine. The manufacturers of synthetic camphor employ turpentine in the process. Pine oil has its largest use at present among the varnish manufacturers, but there is a possibility of its use as a substitute for linseed oil in the manufacture of paints.

# THE CORROSION OF BRASS CONDENSER TUBES

By Paul T. Brühl

EXTRACTS FROM A PAPER PRESENTED BEFORE THE INSTITUTE OF METALS

THE corrosion of brass condenser tubes may conveniently be classed under four heads:

(1) Corrosion proper; where the metal is uniformly removed over the whole surface.

(2) Dezincification; where the zinc, being preferentially more rapidly removed than the copper, the surface of the metal becomes copper-rich in places. The action does not usually extend much below the surface, although it may be so marked as to result in copper "plugs."

(3) Pitting. This is by far the most serious form of corrosion, as it considerably curtails the life of the tube. It is due to galvanic action between the deposit on and the metal of the condenser tube. It may occur in any portion of the tube—that is to say, in the roof and sides, as well as along the floor. It most often occurs in the lowest portions of the tube, because of the natural downward gravitation of any extraneous sediment or of any insoluble product of corrosion.

(4) Erosion. Here the mechanical influence of the stream of cooling water comes into play. Its effect is small and, under ordinary circumstances, uniform.

The following description of five selected cases may serve to illustrate the effects observed in practice:

Specimen 1.—This tube, four years old, was situated in the eighth row from the top; the water circulated through the tube, and, entering at the bottom of the condenser, discharged at the top. The quality was a 70/29/1.* Serious pitting, which in places had pierced the tube, had occurred, the pits being roughly funnel-shaped, with the larger diameter on the water side. Besides the usual corrosion products, both iron hydrate and insoluble matter were present. Specks of spongy copper were common. The pit was not infrequently filled up by the deposit.

Specimen 2.—The tube (70/29/1) was seven years old, and taken from the bottom row. The circulating water passed through the tube, entering at the top of the condenser. The deposit was principally the green basic chloride. Dezincification was not pronounced, for the lustre of a freshly scratched surface was quite normal; the interior surface of the tube was smooth, and one small hole only had formed along a line of season cracking.

Specimen 3.—The tube was a 70/29/1, two years old, and taken from the sixth row from the bottom of the condenser. The circulating water was outside the tube, the inlet being at the bottom of the condenser. The deposit was dark brown in colour, the green oxychloride being practically absent. The edges of the pits seemed to be somewhat steeper than in the two preceding instances.

Specimen 4.—The tube—70/29/1—was five years old, and taken from one of the top rows of the auxiliary condenser. The circulating water passed through the tubes, entering at the bottom and discharging at the top. There was very little deposit and no pitting, the tube having been rejected because of incipient season cracking.

Specimen 5.—The tube—70/29/1—four years old, was one of a number removed at random from the condenser for inspection. The circulating water passed through the tubes, entering at the bottom and discharging at the top. The deposit was rich in iron hydrate and poor in the basic chloride. Dezincification was marked.

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* Copper 70, zinc 29, tin 1.

The examination of these tubes seemed to show that iron hydrate is by far the most injurious constituent of the deposit, being more electronegative than cupric oxide and the basic chloride. Specimen 1, which had a deposit assaying 86 per cent. ferric oxide and 0.27 per cent. insoluble matter, was much more pitted than Specimen 5, which gave the values 1.5 per cent. and 0.41 per cent. for the same impurities. Tube 2, which had been in use for seven years, was hardly affected at all, though well covered with a thin film of the green oxychloride.

### SUGGESTED REMEDIES

A remedy which suggests itself immediately is the use of some protective coating, which should be electro-negative preferably to iron hydrate. Tinning is certainly useful, though by no means a sovereign remedy, because the layer of tin is not always intact. The application of a coating of iron oxide by the method suggested by Mr. Uthemann is excellent, so long as it affords complete protection over the entire surface. But the method appears somewhat risky, as any discontinuity would only aggravate the evil it was intended to counteract.

Another coating is that suggested by B. Müllauer. It is the oxide formed on copper or brass by heating a 5 per cent. sodium hydrate solution to 100 degrees Cent. and adding 1 per cent. potassium persulphate. The article to be coated is immersed in this bath and kept moving to and fro. The deposit so obtained is said to be strongly adherent, but was found to scale off in sea-water after some four weeks. Its protective action, even when the coating was intact, was not very apparent. The plates showed no signs of any action for three or four days, after which the green oxychloride was slowly formed.

T. B. Allen heats the metal in contact with silicon to a temperature below the melting points of either in a non-oxidizing atmosphere. An alloy of silicon and the metal is thereby produced on the surface, which is then said to be more corrosion-proof.

On the whole, however, the question of lessening corrosion by protective coatings does not promise to be of economic usefulness in the case of condenser tubes. The line along which future investigation ought to be made is the study of the alloys of brass with one or even more other substances, with a view to obtaining a mixture which will give the requisite mechanical properties and, at the same time, be the least influenced by sea-water.

### EFFECT OF STRAIN

The irregular distribution of strain on any metallic surface gives rise to differences of potential. In order to investigate this point, short lengths were procured of condenser tubing of the following compositions:

| | Per Cent. | | Per Cent. |
|---|---|---|---|
| Copper | 70 | Copper | 70 |
| Zinc | 30 | Zinc | 29 |
| | | Tin | 1 |

These lengths are wiped down with cotton waste and then dipped into potash and clean water to remove any adherent grease. The potential differences of the two ends were next immediately ascertained by comparison with a standard electrode. The electrolyte used was synthetic sea-water of the following composition:

| | Per Cent. |
|---|---|
| Sodium chloride | 2.7 |
| Magnesium chloride | 0.36 |
| Magnesium sulphate | 0.23 |
| Calcium sulphate | 0.14 |
| Potassium chloride | 0.07 |

As a result of the tests, it was found that no tubes showed a difference of potential between the two ends of more than 0.0002 volt. It was noticed that when a comparatively slight strain was put on such a tube, as by gentle polishing with emery paper, the result was an appreciable rise of potential, which tended to reach a maximum with further polishing. The solution pressure of tubes of the 70/29/1 mixture was very similar to that of the 70/30. The above experiments proved a condenser tube does exhibit differences of potential along its length; but these differences are not sufficiently large and abrupt to explain any corrosion other than a more or less uniform one extending over the whole surface.

### THE EFFECT OF CRYSTAL SIZE

To test the influence of crystal size on the rate of corrosion, six 70/30 plates were taken in the hard-rolled condition, three of them being then annealed at 700 degrees Cent. for ten minutes, the other three at the same temperature for three hours. By this means two sets of plates were obtained, one with small crystals, the other with crystals very much larger, and, as both sets were cut from the same strip, they were, of course, of identical composition. After thorough cleaning with dilute sulphuric acid and emery paper, the plates were weighed and immersed in synthetic sea-water, which was kept stirred on an average for ten hours a day. The loss in weight during the first six weeks shows, on the whole, that a small crystalline structure is conducive to more rapid corrosion; but after some twelve weeks the small crystalline plates, which had hitherto corroded faster, commenced to lose weight more slowly than the large crystalline plates. It would be interesting to ascertain the reason for such a change. The method of manufacture of condenser tubes does not permit of serious variations in the crystalline structure, and therefore crystal size plays a very insignificant part in the problem of corrosion.

### EFFECT ON DIFFERENT ANNEALING TEMPERATURES

In order to obtain information on this point, three specimens of 70/30 brass were annealed in an electric furnace and slowly cooled. The figures show that corrosion increases with the temperature of annealing. It is not good, therefore, for the final annealing in the manufacture of condenser tubes to be unduly long.

### EFFECT OF ROLLING

Brass, on rolling, becomes more electro-positive, or, in other words, more liable to corrosion than the soft metal. The energy imparted is partly evolved as heat and partly stored up in the metal as a kind of potential chemical energy; rolling results in the production of an amorphous modification which is electro-positive to the crystalline metal, and the resultant voltaic effect causes more rapid solution.

To test the effect of rolling, three plates of 70/30 brass were hard rolled to different extents and then immersed in sea-water.

Plate $H_1$ was 0.1 inch thick.

Plate $H_2$ was 0.0875 inch thick.

Plate $H_3$ was 0.075 inch thick.

The loss in grammes per square inch surface was as follows:

| Time in Weeks. | $H_1$. | $H_2$. | $H_3$. |
|---|---|---|---|
| 0-2 | 0.0049 | 0.0053 | 0.0058 |
| 0-3 | 0.0053 | 0.0057 | 0.0062 |
| 0-6 | 0.0083 | 0.0085 | 0.0092 |
| 0-9 | 0.0098 | 0.1010 | 0.1070 |

The figures show clearly how the rate of corrosion increases with the amount of work. If we take a strip of brass bent over in the shape of a U with one limb hard rolled and the other well annealed, and immerse it in dilute HCl, bubbles of hydrogen will be disengaged at the cathode—i. e., on the annealed limb. After some hours the hard rolled limb will be practically dissolved away, whilst the other will have been markedly less attacked. At the junction of metal and liquid corrosion will be very pronounced, the brass being eaten through in a succession of perforations similar to the edges of a postage stamp.

In view of the more rapid corrosion of hard rolled metal, it would appear advisable, considering the thinness of the tube wall, that the last pinch in the drawing of condenser tubes (after the final annealing has been performed) should be as small as possible.

### EXPERIMENTS ON THE CORROSION OF ANNEALED 70/30 BRASS UNDER DIFFERENT CONDITIONS

A series of experiments was undertaken to test the rate of corrosion under varying conditions, such as are met with in practice.

The results leave no doubt that a rise of temperature up to a certain extent is favourable to corrosion, as it increases the reaction velocity between the brass and the sea-water. An increase in the quantity of dissolved air also promotes chemical activity.

The supply of sea-water was changed every third week. Corrosion during this period was most marked just after such renewals, the reaction velocity being proportional to the concentrations of the salts dissolved in the sea-water. As the concentrations must diminish with time, the rate of corrosion, other conditions being constant, must gradually diminish.

### EFFECT OF OIL

The oil used in the lubrication of the piston and slide valves should be composed of hydrocarbons only—that is to say, it ought always to be of mineral origin. It is not advisable to employ organic oils for the purpose, as they possess more body at high temperatures than do the previous class. They are subject, on the other hand, to partial decomposition in the presence of steam, giving rise to glycerine and free acid, which latter becomes a serious danger when in contact with the wall of the condenser tube. Any oil which may find its way into the condenser does so in the form of vapour, owing to the temperature in the cylinder and the continuous rush of steam from it. In the condenser the oil condenses on the tubes in the form of minute globules, which give rise to irregular corrosion.

### EFFECT OF STRAY ELECTRIC CURRENTS

There can be no doubt that stray currents of electricity escaping from imperfect fittings increase the rate of corrosion of condenser tubes by increasing the velocity of removal from the solution of the charged ions. Troubles from this source not infrequently arise both on ships using continuous current to a great extent and in tramway generating stations, where the negative pole is earthed.

The prevention of corrosion from this source can be effected by providing a good path for the stray currents outside the condenser.

The thickness of the deposits on a condenser tube is small, and, as the specific resistances are not of a high order, little opposition will be offered to the passage of an electric current; hence we may suppose that all the products of corrosion, when wet, set up electro-chemical action with the brass. From a consideration of the tests made of the relative position in an electro-chemical scale, it was seen that the most dangerous substances are carbon, cuprous oxide and iron oxide. Iron hydrate and the oxychloride promote chemical action by the absorption of oxygen.

### POLARIZATION AND DEPOLARIZERS

By the passage of an electric current from brass to any of the corrosion products resting on it hydrogen is evolved at the cathode, and, being a high insulator, it will tend, unless removed, to stop any further action. The cathode is said to be polarized by the hydrogen; but as there is always a certain amount of oxygen dissolved in sea-water, the hydrogen will be oxidized and removed to some extent. In the case of a condenser tube, polarization is very unmechanically removed by the swirl of water. Some experiments were carried out to study the rate of polarization in still water, and the results plotted in curves. They show that the substances considered act as depolarizers in a small way by absorbing the hydrogen, but the current which can pass would eventually be very slight.

*The localities of pits.*—A point of interest and importance is the consideration of the circumstances which go to determine the localities where pitting will take place. In the case of 70/30 brass, these localities cannot be supposed to depend upon the distribution of any segregated impurity. In fact, as has been pointed out, the presence in brass of free lead or tin, or, in fact, of any phase besides the *a* phase, would not, *ipso facto,* lead to an increased rate of corrosion, sea-water being the electrolyte. The use of acid completely alters the conditions under which the metal is being destroyed. Here no film can form on it, owing to the solvent action of the acid, and the effect of the products of corrosion on the metal—which is of very considerable importance—is altogether lost. Therefore, it follows that in corrosion experiments it would be better not to use an accelerator.

The positions of the more serious pits are probably governed by two factors—the presence of mechanical defects, such as "spills," and of certain deposits. Even a comparatively small spill in the tube wall will result, when the cooling water ceases to be pumped through, in the formation of a little reservoir, to which air has complete access. It is precisely under these conditions that corrosion becomes very marked. A brass plate which had been immersed in sea-water for several weeks, and which had corroded perfectly uniformly, was then so placed that ¼ inch of the plate stood above the surface of the liquid. In a few days the result was very noticeable; along and just above the junction of liquid and air pitting had occurred, and the metal became quite bright and crystalline in appearance The direct effect of the reservoir would, therefore, be an increased rate of corrosion along a contour, which would narrow as evaporation progressed.

The second cause for pitting is the strong electro-chemical action set up by certain substances. Of these, ferric hydrate and carbon are probably the worst, and of the corrosion products of brass the oxychloride appears to be the most injurious. On two or three of the plates small pits were found under the patches of green deposit after the lapse of four months. The location of these patches depends on the roughness of surface. The causes of abnormally rapid corrosion must be due to the presence of stray currents of some magnitude. Corrosion may be accelerated by the interaction of the various products of corrosion, but it is not rapid and local enough to give rise to pitting.

## CONCLUSION

It is again urged that so important a subject as the corrosion of brass by sea-water, the neglect of which must mean no slight expenditure, should induce steamship companies to keep records bearing on the subject. It has been this lack of data that has hitherto retarded the solution of the corrosion problem.

The conclusions to be drawn from the paper are:

(1) That the presence of air or an increase of temperature up to a certain point accelerate corrosion.

(2) That iron, nickel and small amounts of lead are injurious; tin up to about 1 per cent., large amounts of lead, and aluminium are useful in diminishing corrosion.

(3) That the inlet pipe and the condenser plates should preferably be made of brass.

(4) That the condenser should be protected against stray currents.

(5) Protective coatings are not recommended.

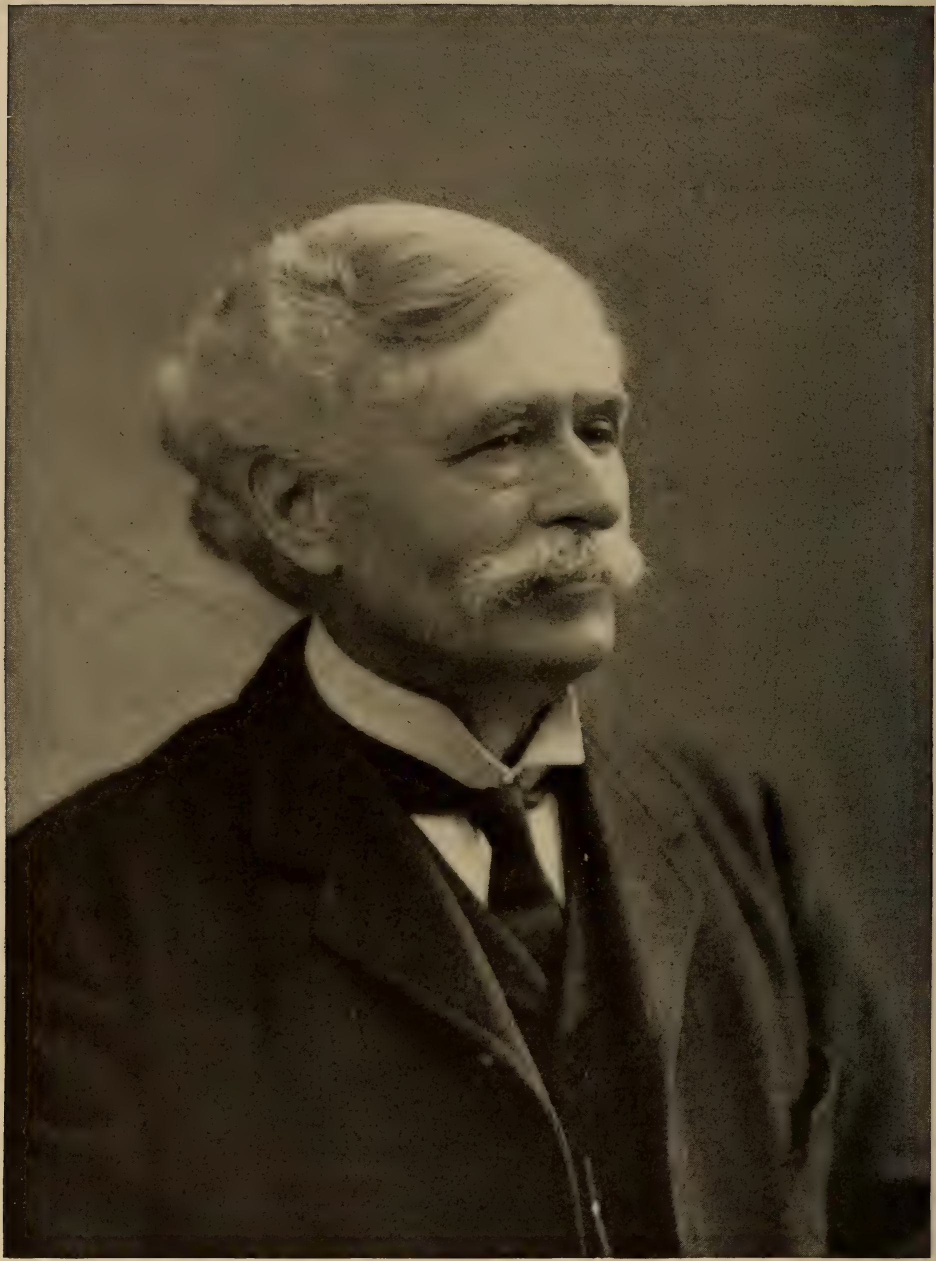
(6) The importance of "spills" cannot be exaggerated.

(7) That the tubes should be flushed with clean water after use.

The extent to which a general business training fits a man for the successful development of a great engineering business is well shown in the career of Mr. Joseph A. Jeffrey, whose portrait we publish this month.

Mr. Jeffrey was born at Clarksville, Ohio, in 1836, and was the son of a farmer who had come to the West from New Jersey. After a general and high school education, young Jeffrey became a clerk in a general store, followed by experience in the banking business in Columbus, Ohio, becoming cashier in the private banking establishment of Messrs. Rickley & Brother. In 1866 he removed to Cleveland and engaged in the general furnishing business, returning to Columbus in 1869, where he organized the Commercial Bank, now the Commercial National Bank of Columbus, in connection with Mr. S. S. Rickley. In 1883 Mr. Jeffrey disposed of his interest in the Commercial Bank and acquired a controlling interest in the Lechner Mining Machine Company, of Columbus. This enterprise had been incorporated in 1878, with a capital stock of $50,000, the capitalization having since been successively increased to $150,000, $300,000, and $3,000,000; the concern bearing the names of The Lechner Mining Machine Company, The Lechner Manufacturing Company, and The Jeffrey Manufacturing Company. The Jeffrey Manufacturing Company has extended its scope until it now manufactures all kinds of heavy mining, conveying, and electrical machinery, and occupies a first-class plant covering about thirty acres of ground, and employing from twenty-five hundred to three thousand men.

Mr. Jeffrey has always taken an active interest in the affairs of his home city, being a trustee of various public institutions, and being a member of the Columbus Club, the Ohio Club of Columbus, and the Middle Bass Club of Lake Erie.



JOSEPH A. JEFFREY,

President of the Jeffrey Manufacturing Company

See Reverse Side.

INDEXED

CASSIER'S MAGAZINE

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VOL. XL DECEMBER, 1911 No. 8

# THE NEW SHIP CANAL AND LOCKS AT SAULT SAINTE MARIE

By James Cooke Mills

DEC 11 1911

THE greatest canals in the world are in the north country of America. By "greatest" is meant the most important in the economics of transportation, for these canals are not the longest, or the deepest, or the most costly, nor did their construction involve very unusual or spectacular feats of engineering. But in point of tonnage passing through them and in their influence upon freight rates throughout the country no artificial waterways ever made approach them, even remotely. It is a surprising statement, but true nevertheless, that these important canals carry a far greater commerce in eight months of the year than is borne by the Suez Canal, the Kiel Canal and the Manchester Ship Canal combined in an entire year. If the commerce of the Erie Canal, the Welland and the canals of the St. Lawrence system be added, the aggregate will still fall short of reaching the enormous tonnage floated by these inland waterways. It reached in 1910 a volume never dreamed of by the early navigators—namely, 62,363,218 tons—an increase of 4,468,069 tons over 1909. The figures that tell of the prospective tonnage of the Panama Canal, when opened to the commerce of the world, seem insignificant when compared with these. In fact, it is hardly probable that the commerce through Panama, in present generations at least, will in a single year equal the commerce of these inland canals at present. With these amazing facts I will introduce to the readers of CASSIER'S the remarkable system of ship canals at the Falls of the Ste. Marys River, in Michigan and Ontario, which have made possible deep-water navigation between Lake Superior and the lower lakes.

The canals at the Sault ("Soo") were dug and the locks constructed by the State of Michigan, the United States Government and the Dominion of Canada in different periods during the last sixty years. Their aggregate cost, including maintenance to the present, is less than $25,000,000. But their operation has effected a saving to the American people in half a century of at least two billions of dollars, and made possible the rapid development of the vast mineral resources of the Lake Superior country and of the rich agricultural sections of the Northwest.

The economics of transportation is a very live and vital problem now before the people, and when it is authoritatively stated that one-sixth of the entire commerce of the United States is now carried by the splendid merchant marine of the Great Lakes

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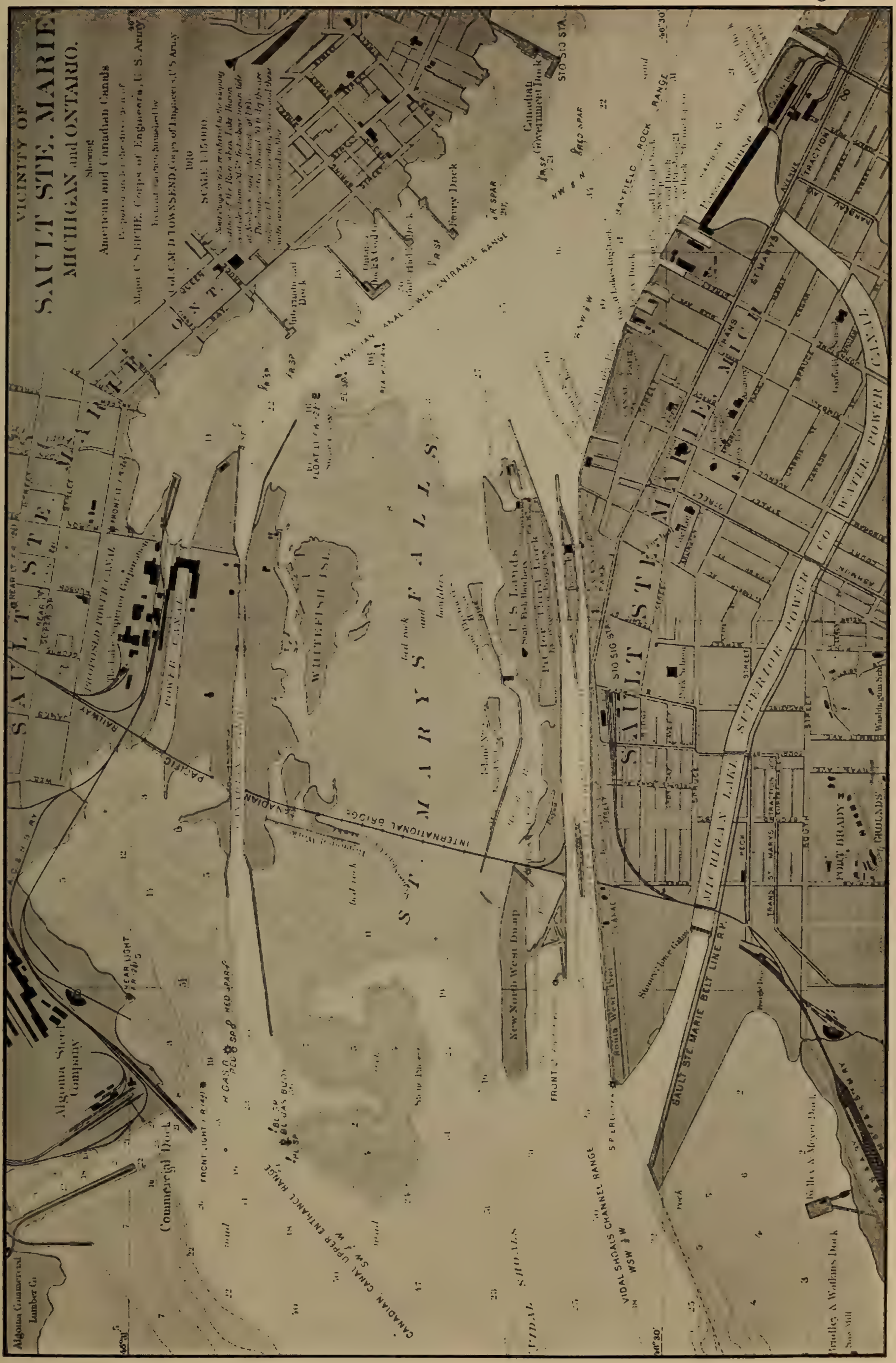
ENTERING THE LOCKS, SAULT STE. MARIE

the importance of having deep channels through their connecting straits to float the present-day huge freighters to their economic draft of 24 feet must be plain to every one. It is, then, of the utmost interest to trace the development of the State and Government engineering works at Sault Ste. Marie, which form the vital part of one of the greatest water highways in the world. And it is of no less moment to know something of what the important project now under way, requiring appropriations of $15,000,000, means to the future of deep waterway transportation and to the industrial development of the North country. What greater returns the people will derive from these improvements to navigation of their free natural waterways in the inland seas the most optimistic of public men do not now attempt to estimate. The growth of lake commerce in the past has so far outstripped the calculations of the most visionary of the old mariners and the prosperity of the Midwest has assumed such a permanent character by its very momentum that conservative minds can scarcely realize the magnitude of the progression or gauge its future.

In the early days of trade in this North country the trappers and fur traders found the sault, or rapids, of the St. Marys River, with its descent of 18 feet within one lineal mile, an insurmountable obstruction to free navigation. For more than a century the sturdy voyageurs portaged their rich cargoes of furs over rough roads or through swamps on either side. The Hudson's Bay Company and the Northwest Fur Company were competitors in securing the valuable products of the wilds, and, in order to gain some advantage over their rivals, the Northwest Company in 1797-8 constructed a canal with a single lock on the north, or Canadian, side of the falls. A description of these works was given by Captain Bruyeres, of the British Army, dated September 10, 1802:

"The landing is in a bay immediately at the bottom of the fall on the nearest channel to the land of the north shore. A good wharf for boats is built at the landing, on which a storehouse, 60 feet long, 30 feet wide, is erected. The wharf is planked, and pathways made and planked all around it. Close to the store a lock is constructed for boats and canoes, being 38 feet long, 8 feet 9 inches wide. The lower gate lets down by a windlass; the upper has two folding gates with a sluice. The water rises 9 feet in the lock. A leading trough of timber, framed and planked, 300 feet in length, 8 feet 9 inches wide, 8 feet high, supported and leveled on beams of cedar through the swamp, is constructed to conduct the water from the canal to the lock. A road raised and planked 12 feet wide for cattle extends the whole length of the trough. The canal begins at the head of it, which is a channel cleared of rocks and the projecting points excavated to admit



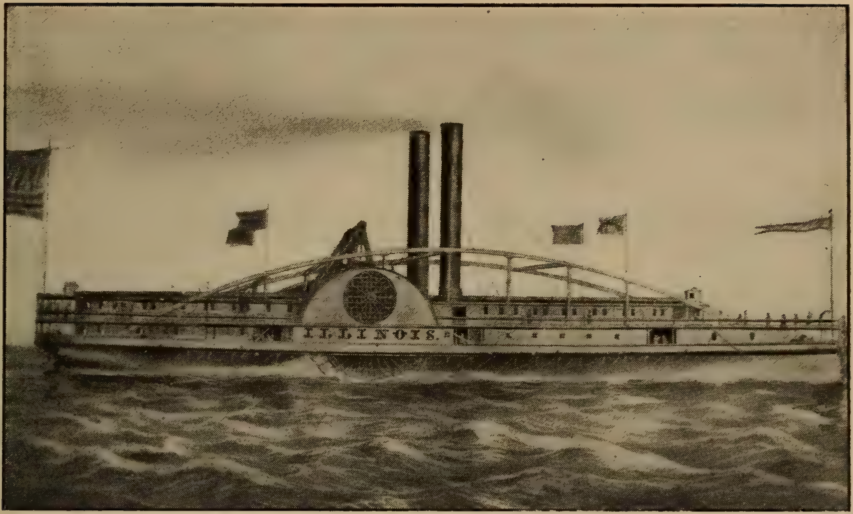
MAP OF THE VICINITY OF SAULT STE. MARIE, MICHIGAN AND ONTARIO, SHOWING AMERICAN AND CANADIAN CANALS the passage of canoes and boats. This canal is about 2,580 feet in length, with a raised bridge or pathway of round logs at the side of it 12 feet wide for oxen to track the boats."

This canal was in use by canoes and bateaux until 1814, when the lock was destroyed, excepting its timber floor and miter sills, by United States troops from Mackinac Island under the command of Major Holmes. The remains were discovered and unearthed in 1889, and are preserved in the original location surmounted by stone walls and flooded to prevent rapid decay of the once stout timbers.

Settlement of the Northern wilderness during the first half of the last century was slow, and was discouraged by the fur companies, as it meant the extinction of fur-bearing animals and loss of trade. The struggling hamlet of Sault Ste. Marie, on the American side of the falls, although the first permanent settlement on the continent west of Montreal, was then as remote from the outer world as a place of abode on the shores of Hudson's Bay would be to-day. What traffic there was between the cold and forbidding region about Lake Superior and the lower lake settlements was laboriously carried over the portage by wagons drawn by oxen, but afterward a rude tramway, upon which cars were run, served the purpose. But the discoveries of rich copper and iron deposits in 1843-4 along the shores of the inland ocean started immigration to Upper Michigan, so that by '49 about 1,600 explorers had settled there. In 1851, 12,600 tons of merchandise, machinery, copper and bloom iron passed over the portage, to the value of $1,675,000.

A wave of land speculation swept the country about this time, and in 1853 the State of Michigan, upon receiving a grant from the government of 750,000 acres of land in the upper peninsula, was able to contract with an Eastern syndicate for the construction of the State Canal. This was the first ship canal made within the borders of the United States, and it was dug under great difficulties. The early canal builders were mechanical giants, who, like their predecessors who built the

THE FIRST TRIP OF THE SEASON UP THE CANAL, STUCK IN ICE JAM


THE ILLINOIS, BUILT IN 1837-8. THE FIRST VESSEL LOCKED THROUGH STATE CANAL, JUNE 18, 1855

Grand Erie about thirty years before, had only the wheelbarrow, shovel, pick and such simple and crude devices to dig the canal prism, and only the little crane, operated by human strength, to lift the massive blocks of stone in place. But with all these drawbacks to an early completion of the undertaking, as many as 1,500 men were employed at times, and, overcoming many serious obstacles interposed by the isolation of the locality and the severity of the winter in the northern latitude, the great work was completed in only two years. The canal was slightly over a mile in length, 64 feet in width on the bottom and 100 feet on the water surface, 13 feet in depth, and was excavated through rock and shale. Near the foot of the canal were two tandem locks of masonry, each 350 feet long and 70 feet wide, having 11½ feet of water on the sills and a lift of 9 feet.

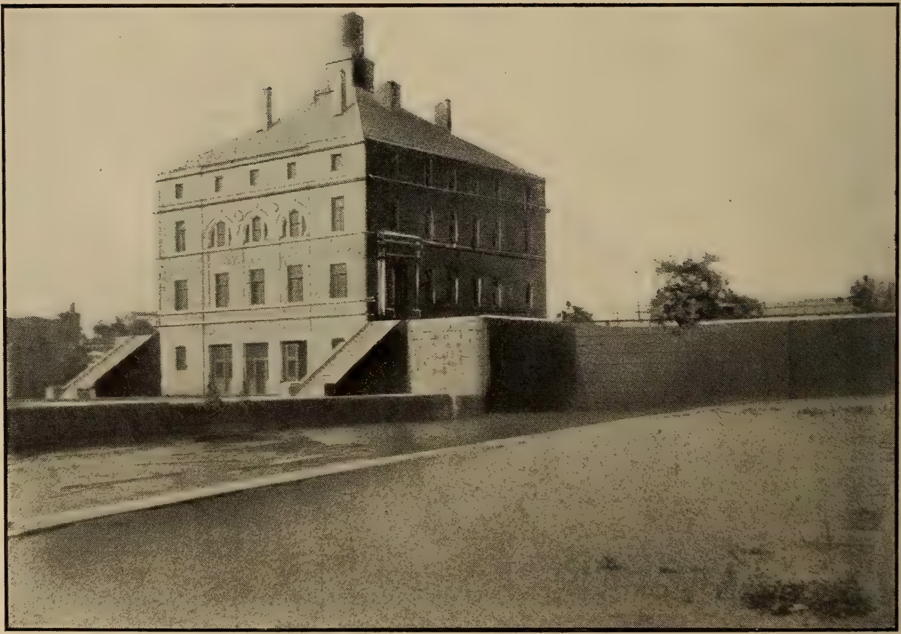
The machinery for opening and closing the gates of these locks was the most simple and primitive kind. There was attached to each gate at the miter post a strong line for opening it, while a boom similarly connected to the gate served to close it. The power was applied through a capstan by manual labour, and the gates could be opened or closed in three or four minutes. The lock chambers could be filled or emptied in about seven minutes, and a tug and tow of three sailing vessels could be locked through at one time. The class of vessels built in the fifties and early sixties were of about 500 tons capacity, and, when fully loaded, drew from 12 to 13 feet of water, which was slightly more than the depth of the locks afforded. The cost of this important work was $1,000,000.

The canal was opened to Lake Superior commerce on June 18, 1855. The side-wheel steamboat *Illinois,* Captain Jack Wilson, was the first vessel to lock through, followed soon after by the steamer *Baltimore* and the brig *Freeman.* During the balance of the navigation season 193 vessels passed through the canal, carrying 14,503 tons of freight and 8,295 passengers. This was the beginning of modern commerce of the inland seas as we know it to-day. Twenty-six years later, when the new Weitzel lock was opened to navigation, the upper lake commerce had increased to 1,567,741 tons, carried in 4,004 vessel passages, and the passengers numbered 24,671. From that time the waterway commerce increased by still greater strides, and in thirty years had multiplied forty-fold.

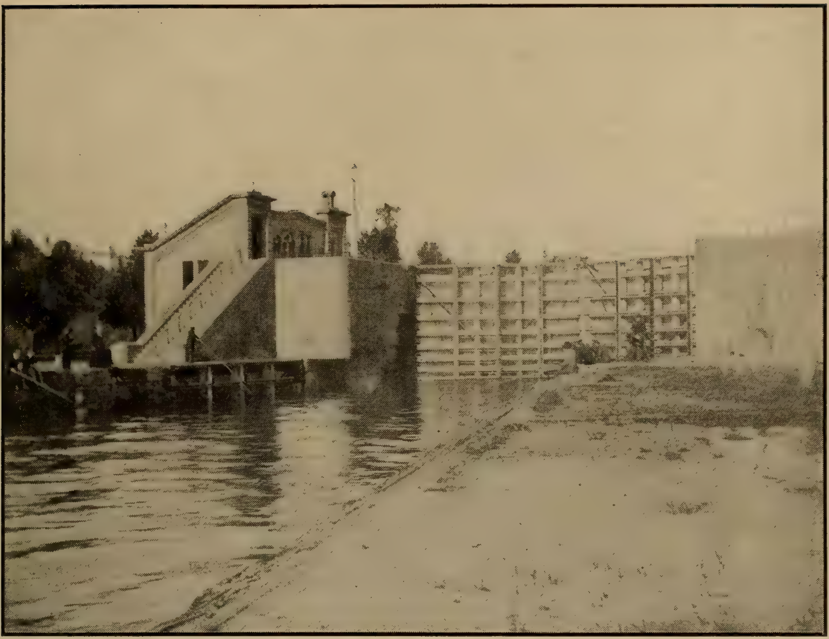
After thirty-two years of constant service the State locks became inadequate by limitation of size to pass the type of vessels then plying the lakes, and they were torn out to make room for the new lock, which is the largest in the world. In supervising this work in 1887, General Orlando M. Poe, who was the designer and builder of Spectacle Reef Light, in Lake Huron, which is a monument to his skill, expressed his appreciation of the excellence of the first canal locks in these glowing terms:

"On the whole, the canal was a remarkable work for its time and purpose. The construction of the locks especially bore evidence of a master's hand in their design and execution, and every step in their destruction reveals the excellence of the workmanship, the honest character of the materials employed, and the faithful compliance with the conditions of the contract under which they were built, not merely in its letter but in its spirit. All honour, then, to every man connected with their design and construction. They were long in advance of their day, and if commerce had not outgrown their dimensions they would have done good service for a century.

"I must confess to a feeling of great regret that it has become necessary to destroy these first locks. Inanimate though they are, they seem to appeal to every sentiment of respect. They had never failed to respond to any demand within their capacity; they had contributed, in a higher degree than any other one factor, to the development of the country to the westward of them, and having done such good work are now to be obliterated in the interest of that very commerce they did so much to establish. The man who, knowing their history, can see them go without compunction, is made of other stuff than I am, and, if an engineer, has no genuine love for his profession nor pride in the achieve-



THE LOCK POWER HOUSE, SHOWING LOWER GATES OF POE LOCK



THE OLD WEITZEL LOCK; LOWER GATES CLOSED

ment of those who successfully apply its teachings to the best examples of his art."

Early in the seventies it became evident that the State Canal would, in a few years, be inadequate to meet the increasing commerce between Lake Superior and the lower lakes, and measures were taken to provide a new lock and an enlargement of the old canal. The Federal Government undertook this work and increased the width of the canal to 160 feet and the depth to 16 feet, and replaced the stone slope walls with timber piers having a vertical face. In 1876 it began the construction of the Weitzel lock, a few feet south of and parallel to the old locks. This lock is 515 feet long, 80 feet wide, narrowing to 60 feet at the gates, and has 17 feet of water on the miter sills at normal lake levels. It was named in honor of General Godfrey Weitzel, U. S. A., who was in charge of the work. The new lock was opened to navigation on September 4, 1881, by the passage of the steamer *City of Cleveland.* These improvements, all told, cost $2,150,000. The Weitzel lock has a capacity of about 15,000,000 tons, and still serves a useful purpose in locking through the smaller classes of vessels and those to 500 feet length passing light. This, of course, reduces the congestion of traffic through the great Poe lock.

This great engineering work, which was named after General Poe, who was district engineer, was undertaken in 1887 and completed in 1896. The lock is 800 feet long, 100 feet wide, and has a depth of 22 feet at normal levels. It carries the largest proportion of the Lake Superior commerce, or about 35,000,000 tons, passing in one lockage four vessels, two abreast, of maximum length 380 feet, a width of 45 feet, and carrying in the aggregate fully 20,000 tons. The operation, including movement of vessels in and out of the lock, which must be done very slowly and cautiously, the filling or emptying of the chamber, and the closing and opening of the gates, requires about thirty minutes. The canal itself was deepened to 22 feet and the basin above the locks widened, to accommodate the largest type of vessels then plying the lakes. Since the third day of August, 1896, when the Poe lock was opened to commerce, it has proved the greatest economic factor in waterway transportation. The 600-foot ore and grain carriers now load to about 20 feet draft (the limit imposed by present lake levels), stowing in their capacious holds more than 13,000 tons of ore or 420,000 bushels of wheat. When it is considered that for every inch of increased draft over 20 feet the 600-foot freighters can stow 150 tons, the economic advantage of providing 24-foot channels through the connecting waterways of the lakes is plainly evident. Their cargo capacity at 25 feet draft, which will be possible in a few years, is thus increased to 20,000 tons net.

The cost of the Poe lock and the canal improvements amounted to $4,765,000, which brought the expenditure on the American side of the falls to about $8,000,000. But the canal also practically includes those parts of the channels through St. Marys River which have been improved through shoals of rock, sand and clay. At the time of the opening of the State Canal the maximum depth over these obstructions did not exceed 12 feet, but from 1882 to 1903 there was expended on the improvements in Hay Lake and the Middle and West Neebish channels the sum of $4,000,000. The new route through Hay Lake provides a much straighter channel, is 11 miles shorter than the Lake George route, and eliminates a number of short turns in the treacherous channel. The minimum width through the rock cuts is now 300 feet, widening to 1,000 feet at angles and dangerous turns, and with a depth of 21 feet at lowest stage of water. The dredged areas now total 34 miles in length, and have cost since 1903 nearly $4,000,000, making the total expenditure to the beginning of the present project about $16,000,000, a

UPPER END OF WEITZEL LOCK. GATES OPENING TO PASS FREIGHTER UP, WITH CANAL FREIGHTER AT RIGHT WAITING TO LOCK DOWN sum which has been returned a hundred-fold in direct benefit and saving to the American people. As an instance, I may cite the cost of the freight-ton through the canal has been reduced from 13.57 mills in 1882 to 3.53 mills in 1909; and in 1906 it was as low as 1.96 mills.

But the great strides taken in shipbuilding on the Great Lakes demand even wider and deeper channels in river and harbour, in order that the present leviathans may load to their full cargo capacity. To this end the present work in St. Marys River, which has been under way since 1907 and will not be completed until 1917, is of the utmost importance. It consists of widening and deepening the canal above the locks, work of the same general character in Middle Neebish channel, in the lower river, and the construction of the new canal and the great Davis lock on the edge of the falls. The fourth lock, the plans for which are now being prepared, will be placed still further north toward the rapids, and will be fed by the new canal. Work on this lock will be started as soon as practicable.

The first undertaking in this project, which resulted in greatly increasing the safety of vessels locking through the canal, was completed in the summer of 1910. It was a work of some magnitude, the excavation being done in the "dry" behind strong cofferdams. Beginning at a point near the north pier and a little above the upper gates of the Poe lock, the excavation extended westerly to the head of the canal, which was lengthened to make the waterway 1 3/5 miles long. A new north pier was then constructed of concrete and backed with clay. The width of the canal was thus increased by a wedge-shaped slice a mile long, the point of which was near the lock gates and the top of which, about 140 feet across, was at the head of the canal. This left the swing pier of the International Bridge and the new movable dam in the middle of the canal instead of on the north pier. The new prism was cleaned out to the required depth of 25 feet, water was turned in, the cofferdams removed, and the old north pier taken out. When the old prism had been dredged out to a uniform depth of 25 feet the enlargement was completed. The canal is now 500 feet wide at the upper entrance, 270 feet at the basin, 108 feet at the lock gates and 1,000 feet wide at the lower entrance.

The work on the Middle Neebish channel under four contracts has progressed rapidly to completion, and the last section, at the Sailors' Encampment, was finished in the fall of 1910. The improved channel is 300 feet in width, and has 22 feet of water over the rock at mean low stage level of Lake Huron. The improvement to the channels of this great water highway will relieve much of the congestion to traffic of the two constantly passing processions, both day and night, of the

MEN FISHING BELOW THE LOCKS. SAULT STE. MARIE

STEAMER NORTH WEST LOCKING THROUGH SAULT STE. MARIE

great stream of merchant marine.

But as important as this improvement is to the lake shipping, the greatest project is the new canal with its mammoth locks, which is located just north of the present works. The excavation of the pit for the new third lock has been in progress for some months and is now completed. It is a deep trench cut in solid rock, nearly a third of a mile in length, about 150 feet in width on the bottom, and is parallel to the Poe lock. The work was done by the open or dry method of excavating, by the use of steam shovels and steam rock drills. Within this pit the new Davis lock, named in honour of Col. C. E. L. B. Davis, U. S. A., who was in charge of the district in 1908, is being constructed of monolithic concrete. The lock chamber will be 1,350 feet long, 80 feet wide, and will provide for a depth of water at extreme low water datum of 24.5 feet. These dimensions will permit of the stowing in one lockage of two of the lake leviathans, 600 feet or over in length, of 60 or more feet beam, and carrying cargoes of ore, coal or grain aggregating 40,000 tons.

The width of the new lock, however, will not permit of two big freighters locking through abreast, as is frequently done in the Poe lock, with a width of 100 feet. But experience has shown that much time is lost by this method of locking, as vessels must move very slowly and cautiously in entering and passing out of the lock, or great damage will result. Time is an all-important factor in the economical operation of the giant ore carriers, and it is expected that the new locks, with their greatly increased length, will gain more in quick lockages of two or more vessels, end to end, than they will lose in tonnage of a larger number of vessels stowed abreast. The lock gates and the machinery for their operation will be slightly modified types of the installations of the famous Poe lock, which have never failed in fifteen years' service to meet every demand made of them.

The new canal, which is being excavated through rock and shale, will have, including the lock, a length of 1¾ miles, a clear width of from 260 to 300 feet, and a depth of 25 feet at low water datum. The International Bridge will have a bascule or roller lift span over the new canal, eliminating the objectionable centre pier, thus providing an unobstructed channel of practically uniform width throughout. In view of the rapidly increasing number of 600-foot freighters and a large type of upper lake liners, this feature of the canal for their safeguarding is of the utmost importance. The present plans, in fact, provide for an enormous expansion of lake commerce, and, with the Canadian canal and lock, will be amply sufficient until the time when the Lake Superior commerce exceeds 200,000,000 tons annually.

The practical necessity of making a separate and free waterway to feed the new locks, as explained by Col. C. McD. Townsend, Corps of Engineers, U. S. A., is due to the requirements of a uniform and dependable supply of water at all times, and also to the excessive currents which would be roused by taking water from the old, enlarged canal. Experience has shown that when both the Weitzel and Poe locks are being filled at the same time the drawing down of a great quantity of water in the upper canal creates strong currents at the International Bridge, which endangers passing vessels at that end. This condition will be largely avoided by the new canal, with its independent supply of water. Another objection to one canal to feed four locks lies in the possibility of having to close navigation entirely on the American side for a time in the event of the sinking of a vessel in the canal or the wrecking of a lock gate. With independent canals for each system of locks only two locks would be useless for the time being, the probability of such an accident in both canals at the same time being very remote.

Besides the canals on the American side of the international line there is a large ship canal on the Canadian side, made and operated by the Dominion Government. Can-

LOCK-PIT EXCAVATION FOR NEW LOCK AND CANAL, SAULT STE. MARIE ada is thoroughly awake to the importance of cheap transportation, and has contributed a large share to the present deep-water navigation of the unsalted seas. As a matter of fact, the Dominion Parliament has appropriated to the present for canal improvements a sum equal to that used by the United States for a like purpose. In each case it is something like $100,000,000; and the future will demand still greater expenditures to keep pace with the development of the north country made possible by these very improvements. The Canadian canal is 1⅛ miles long, 150 feet wide and 22 feet deep, and the lock is 900 feet long, 60 feet wide, and has a depth of water of 22 feet on the miter sills. The works were constructed in the years from 1888 to 1895, and were opened to commerce on September 9, 1895. The lock affords about 8 inches greater depth of water than the Poe lock, and for this reason nearly all the 500-foot and 600-foot freighters now load for this lock. It means an additional cargo capacity of from 1,000 to 1,200 tons for each. The average number of vessels passing the three locks at the St. Marys Falls canals is 84 daily, and of these 27 were locked through the Canadian canal and 57 through the American canal. The former canal carried a tonnage in 1910 of 36,435,557, or 58 per cent. of the total, although more than 90 per cent. of it was freighted in ships flying the Stars and Stripes.

To look upon these great canals, which reflect the skill and ingenuity of American engineers, and the double procession of splendid ships constituting our inland merchant marine, carrying the rich products of industry, must fill every full-blooded citizen with pride that they are the works of a powerful nation of which he is a mere atom; and he must feel a thankfulness that he lives in a progressive age in which such advance in trade and commerce is made.

# THE MARINE STEAM TURBINE

Hon. Sir Charles A. Parsons, K. C. B., LL. D.

THE development of the marine steam turbine during the last few years was dealt with as recently as July of the present year in a paper read at the jubilee meetings of the Institution of Naval Architects, and there would appear to be very little to add either from an historical or technical point of view.

In view, however, of the changes that have taken place in the application of the turbine to different classes of vessels, a brief review of recent developments in the general design and disposition of the machinery may be of some interest.

Considerable differences exist in the service conditions of various classes of ships, demanding different designs and arrangements of propelling machinery. In high-speed mercantile vessels, however, the arrangement of machinery on three shafts, with one high-pressure and two low-pressure turbines, as fitted in the first mercantile vessel (the *King Edward*) some ten years ago, still proves the most suitable, except for vessels of large power. In the latter case, the four-shaft arrangement of turbines has been adopted, *i. e.,* one high-pressure and one low-pressure turbine on each side of the vessel, comprising two complete sets of engines.

The development that has taken place in the turbines for this class of vessel has been very largely in the matter of details of construction, as a natural outcome of experience gained, to increase both the mechanical and steam efficiency; and considerable economies have been effected by these modifications in design and details.

In some recent vessels of large power, having four shafts, the high-pressure turbines have been placed in series, and this arrangement may come very much in favour in the near future, in view of the gain in economy obtainable by such an arrangement.

In vessels of intermediate speed, where economy is of primary importance, the combination system of reciprocating engines and low-pressure turbines is still favoured.

All the vessels at present built and fitted with the combination system have triple screws with twin reciprocating engines and one low-pressure turbine. Each reciprocating engine drives a wing shaft with the low-pressure turbine on the centre shaft, the low-pressure turbine taking the exhaust steam from both reciprocating engines.

At the present time there are under construction one vessel in France and another in England, having four shafts with two reciprocating engines and two low-pressure turbines, the reciprocating engines driving the inner shafts and the turbines the wing shafts.

The service results of recent vessels fitted with the combination system have shown that this arrangement of machinery effects a saving of at least 12 per cent to 14 per cent in coal consumption as compared with similar vessels fitted with quadruple engines.

Hitherto the turbine has been used almost exclusively in vessels of high and moderate speeds, but within the last two years a further field has been opened in its application in association with gearing to vessels of low speeds.

The application of geared turbines and the experience gained in the steamer *Vespasian* are fully dealt with in papers read before the Institution of Naval Architects in 1910 and 1911, but supplementing the data given in the papers referred to, it may be mentioned that the *Vespasian* continues in regular service and has now completed some fifty-three voyages between the Tyne and the Continent, covering a distance of about 32,000 knots. The turbines and gearing are working with entire satisfaction, and no appreciable wear in the teeth can yet be observed.

For slow-speed vessels the arrangement adopted in the *Vespasian,* comprising one high-pressure and one low-pressure turbine driving one propeller shaft, appears to be the most suitable.

The two steamers for the London & South Western Railway Company which are at present under construction will have twin screws, with a high and low-pressure turbine geared on to each screw similar to the arrangement in the *Vespasian.*

As a result of experience in the *Vespasian,* gearing promises to play an important part in marine turbine installations in the near future, in view of the substantial increase in economy that is desired by its use.

The problem set in connection with the design of warship machinery is a much more complicated one than for merchant ships. Merchant ships nearly always steam at or about their maximum speed, whereas in war vessels the realization of economy at the lower speeds at which these vessels are required to cruise, as well as economy at the higher speeds, has a considerable influence on the design of the turbines. Then, again, in battleships and cruisers the general design, disposition of the turbines, and number of shafts are governed by the different arrangements of water-tight subdivision, magazines, etc., in these ships.

In all the earlier destroyers, with the exception of the *Viper, Cobra,* and *Velox,* cruising turbines were fitted, in addition to those for use at the higher powers, to assist the economy at low powers. Figure 1 shows the arrangement adopted, consisting of a high-pressure and two low-pressure main turbines, each driving a shaft with cruising turbines fitted in series, one on each of the low-pressure shafts.

Figure 2 shows a typical arrange-

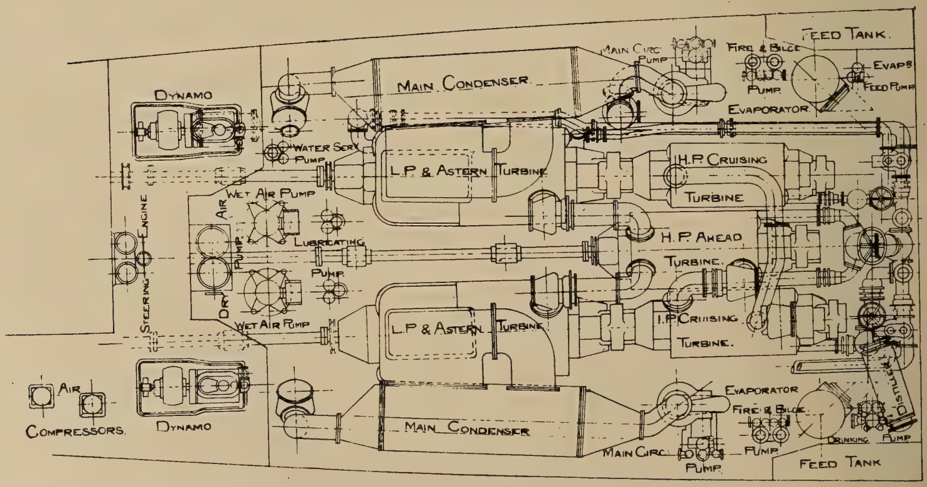


FIG. 1.—GENERAL ARRANGEMENT OF TURBINE MACHINERY FITTED ON TORPEDO BOATS

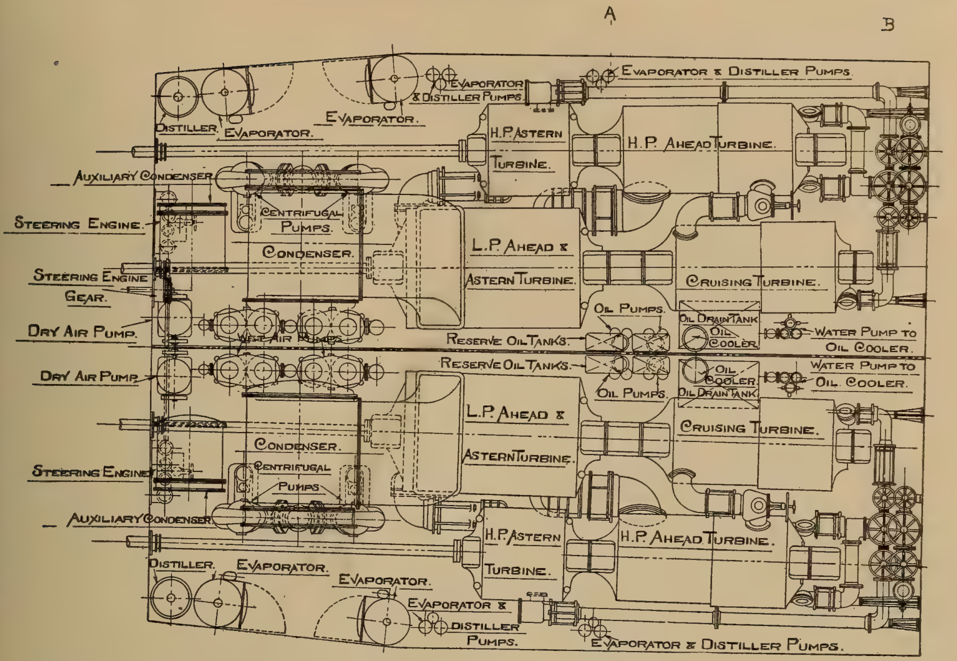
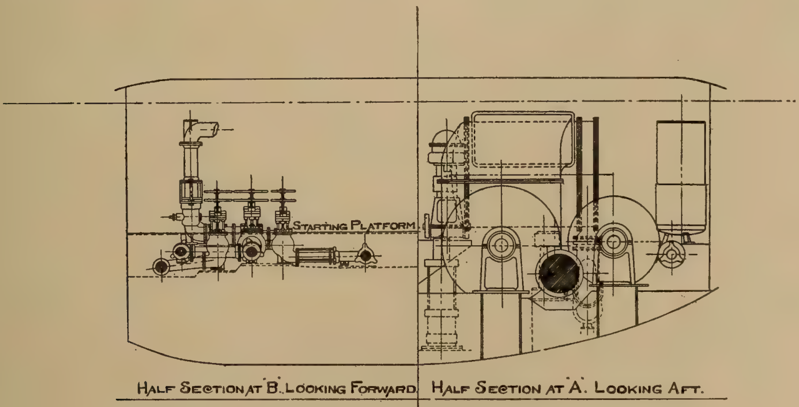


FIG. 2.—TYPICAL ARRANGEMENT OF TURBINES ADOPTED IN THE EARLIER BATTLESHIPS AND LARGE CRUISERS

ment of turbines adopted in the earlier battleships and large cruisers. In these vessels cruising turbines were fitted in parallel, but in some recent designs these cruising turbines have been omitted and the weight and space saved due to their suppression has been utilized to increase the efficiency of the main turbines. The result of this modification in the design has been to increase the efficiency of the main turbines at full power. The influence of this increased efficiency at full power is felt down to about half power. Below half power, however, the efficiency of the turbines is somewhat less than that of the earlier combinations with cruising turbines, especially when these cruising turbines are placed in series.

In certain classes of ships, where


Starting Platform
Half Section at B. Looking Forward
Half Section at A. Looking Aft.

HALF SECTION OF A, LOOKING AFT, AND HALF SECTION OF B, LOOKING FORWARD; TAKEN FROM FIG. 2

the radius of action over a range of low powers is of great importance, due to their limited coal or oil storage, cruising turbines in series are usually adopted. Then, again, where economy at or about a given cruising speed is of primary importance, the fitting of small reciprocating engines for this special cruising speed in combination with the main turbines would give exceptionally high economy under these conditions. Such an arrangement was fitted some years ago in the destroyer *Velox* with excellent results for the speeds for which the combination was designed. Another and more recent alternative arrangement to meet such a condition with a somewhat wider range of cruising speeds is the gearing of cruising turbines to the main turbines. Such an arrangement of geared cruising turbines would effect a saving of between 25 per cent and 30 per cent in large war vessels as compared with ordinary direct-coupled cruising turbines.

In recent destroyers and small cruisers the general tendency in many navies has been towards the fitting of twin screws in lieu of triple screws previously adopted in this class of vessel. This has led to the adoption of a design of turbine consisting of one or more velocity compounded impulse stages at the high-pressure end of the turbine with reaction blading for succeeding stages. Figure 3 shows a longitudinal section of such a turbine. Reversing turbines follow a similar construction, as will be seen from the illustration referred to.

Figures 4 and 5 illustrate the application of the impulse-reaction design to a destroyer with twin screws, each turbine being complete as an independent unit with an impulse wheel at the high-pressure end of the ahead and astern turbines, Figure 4 showing the turbines in one engine room, and Figure 5 with two engine rooms, one abaft the other. Either of these arrangements is also applicable to small cruisers, where the

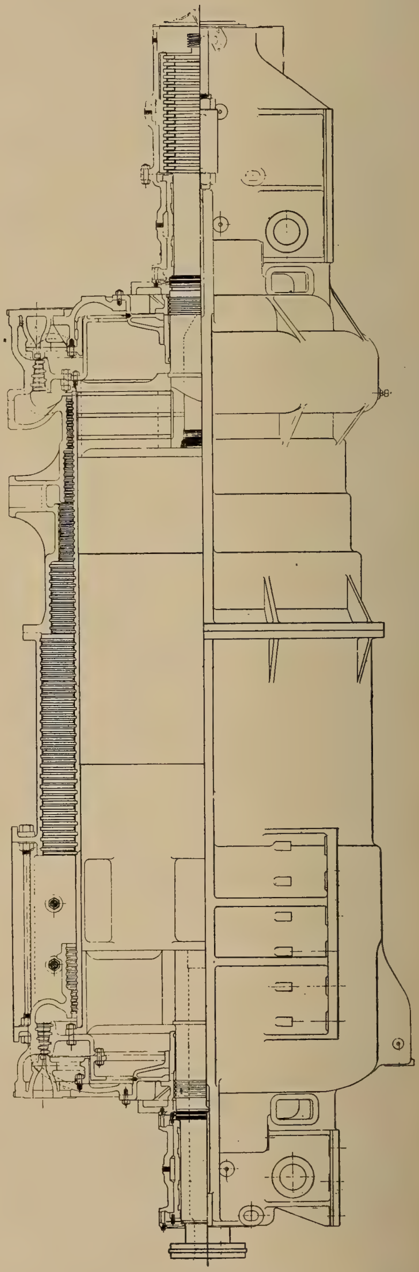


FIG. 3.—A LONGITUDINAL SECTION OF TURBINE USED ON SMALL CRUISERS

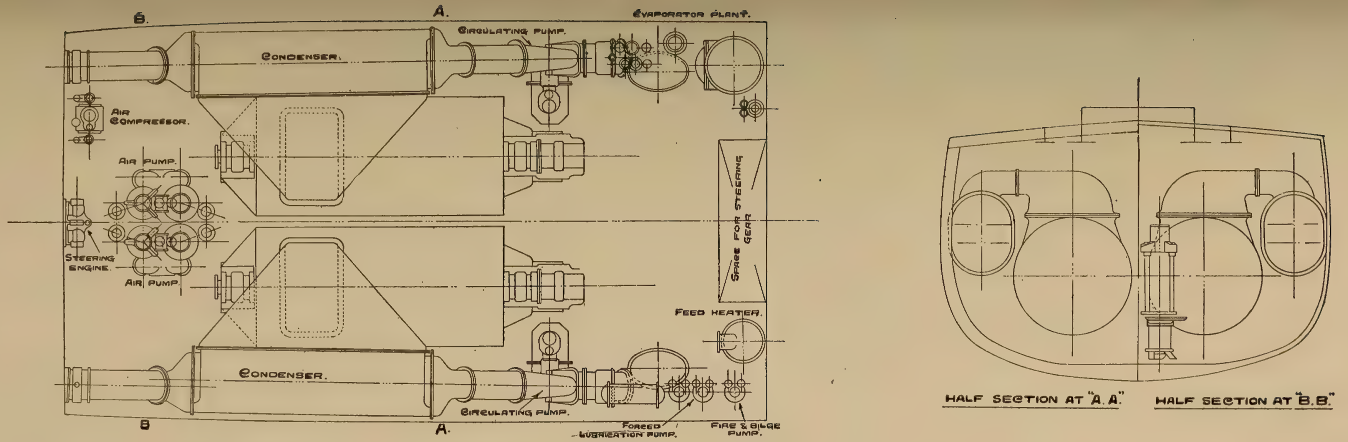


FIG. 4.—ILLUSTRATION OF TWO-SHAFT GENERAL ARRANGEMENT OF TURBINES USED ON TORPEDO-BOAT DESTROYERS

Each turbine being complete as an independent unit with an impulse wheel at high-pressure end of the ahead and astern turbines.

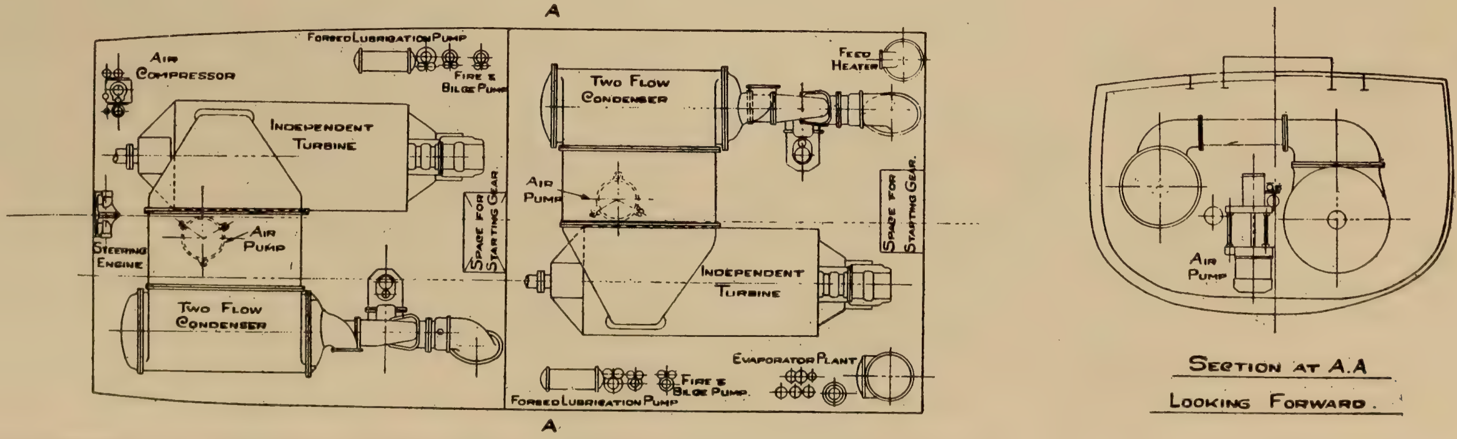


FIG. 5.—TORPEDO-BOAT DESTROYERS WITH TWO-SHAFT GENERAL ARRANGEMEMENT OF TURBINES WITH INDEPENDENT UNIT ON EACH SHAFT, ARRANGED IN TWO ENGINE ROOMS

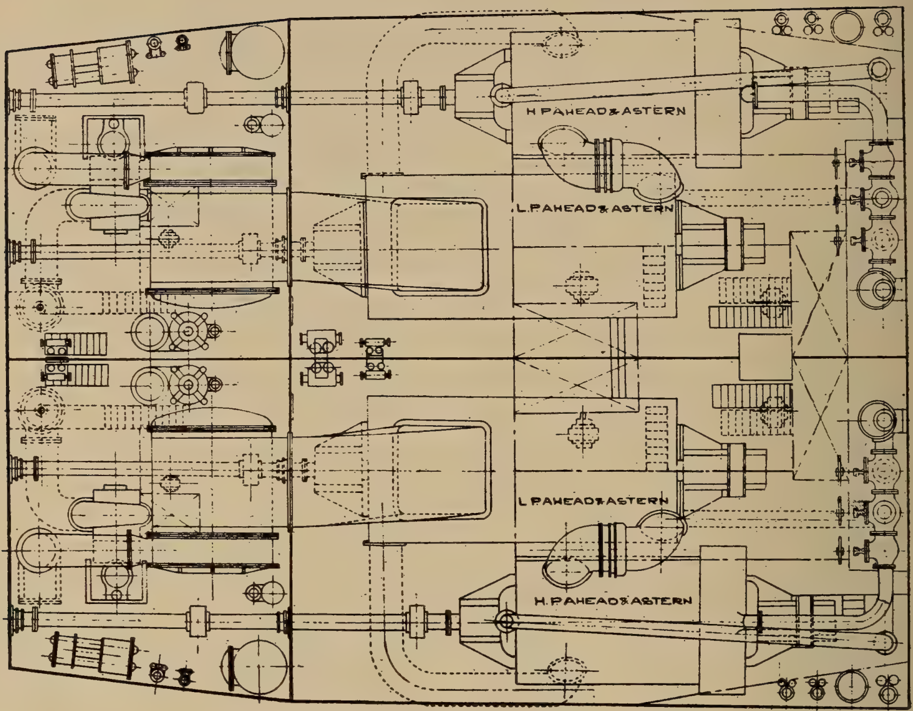


FIG. 6.—OUTLINE OF FOUR-SHAFT ARRANGEMENT OF TURBINE MACHINERY WITH IMPULSE WHEEL AT HIGH-PRESSURE END OF HIGH-PRESSURE AHEAD AND ASTERN TURBINE

power is not so high as to render the units too large and heavy for twin screws.

The turbines above described are also suitable for the high-pressure turbines of four-shaft arrangements, where there is a high-pressure and a low-pressure turbine on each side of the ship, as shown in Figure 6. This arrangement is applicable for all battleships and armoured cruisers and for small cruisers of high power. With the impulse-reaction design of turbine it is possible to combine the high-pressure reversing turbine with the high-pressure ahead turbine in one casing, each exhausting separately to its corresponding low-pressure unit. Such a construction as shown in Figure 6, as above, is being carried out at the present time for battleships.

With the high-pressure turbine having an impulse stage and reaction blading for succeeding stages, the efficiency at full power will remain about the same, and at small fractions of power the steam consumption will be generally intermediate between that of the arrangements having and not having cruising turbines.

Other combinations of the turbines previously referred to are possible to meet special conditions of service or of water-tight subdivision, but generally the arrangements as described cover a very large proportion of the different types of war vessels of the navies of the world.

In conclusion it may be mentioned that economy in steam consumption has been obtained in recent designs by increasing the coefficients of the turbines, and a still further increase in the size of the turbines in the future, where space permits, would tend to futher economies without any additions to the total weight of machinery.

# THE PANAMA AND ERIE CANAL LOCKS—A CONTRAST

By Day Allen Willey

TWO engineering works are in progress at the present time—both American projects. But one is international, while the other is due to the enterprise of a single State, which is expending $100,000,000 to complete it—nearly a third of the estimated cost of the Panama.

The Panama and Erie Canals present a very interesting comparative study of the ability of the engineer. The outlay of $350,000,000 by the United States to excavate a ship waterway connecting the oceans through the Isthmus of Panama means the employment of a great variety of machinery. The makers of steam shovels, dredges, aerial conveyors, explosives, compressed air drills, electric and steam motors, have placed the most modern and most powerful equipment in operation, and the apparatus includes new ideas designed especially to aid in this work.

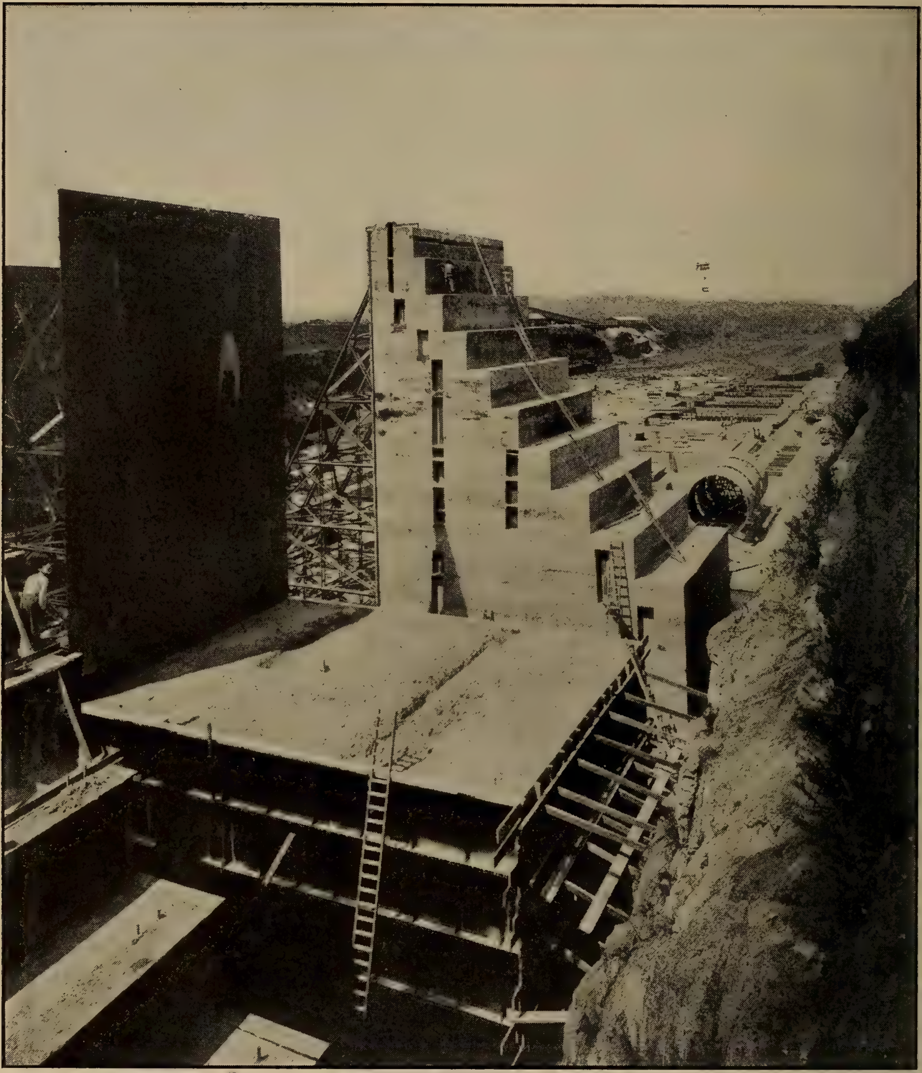
The project is indeed varied. The total length of the canal to be made from sea to sea is 50½ miles, with a maximum width on the bottom of 1,000 feet. The land excavation is 40½ miles of cutting through rock, sand and clay, leaving 10 miles of channel to be deepened to reach the sea at either end. Some of the other great construction dimensions are these:

| | |
|---|---|
| Locks, usable length | 1,000 feet |
| Locks, usable width | 110 feet |
| Gatun Lake area | 164 square miles |
| Gatun Lake, channel depth | 84 to 45 feet |
| Excavation, estimated total | 174,666,594 cubic yds. |
| Concrete, total estimated for canal, | 5,000,000 cubic yards |

So many are the spectacular features connected with the Panama that the engineering world is watching its progress. For example, the Gatun, the greatest rock and earth-fill dam ever designed, is alone a notable achievement. Forming Gatun Lake by impounding the waters of the Chagres and other streams, it will be nearly 1½ miles long, measured on its crest, nearly ½ mile wide at its base, about 400 feet wide at the water surface, about 100 feet wide at the top, and its crest, as planned, will be at an elevation of 115 feet above mean sea level, or 30 feet above the normal level of the lake. The interior of the dam is being formed of a natural mixture of sand and clay, dredged by hydraulic process from pits above and below the dam and placed between two large masses of rock and miscellaneous material obtained from steam-shovel excavation at various points along the canal. The top and up-stream slope will be thoroughly riprapped. The spillway is a concrete-lined opening, 1,200 feet long and 300 feet wide, cut through a hill of rock nearly in the centre of the dam, the bottom of the opening being 10 feet above sea level.

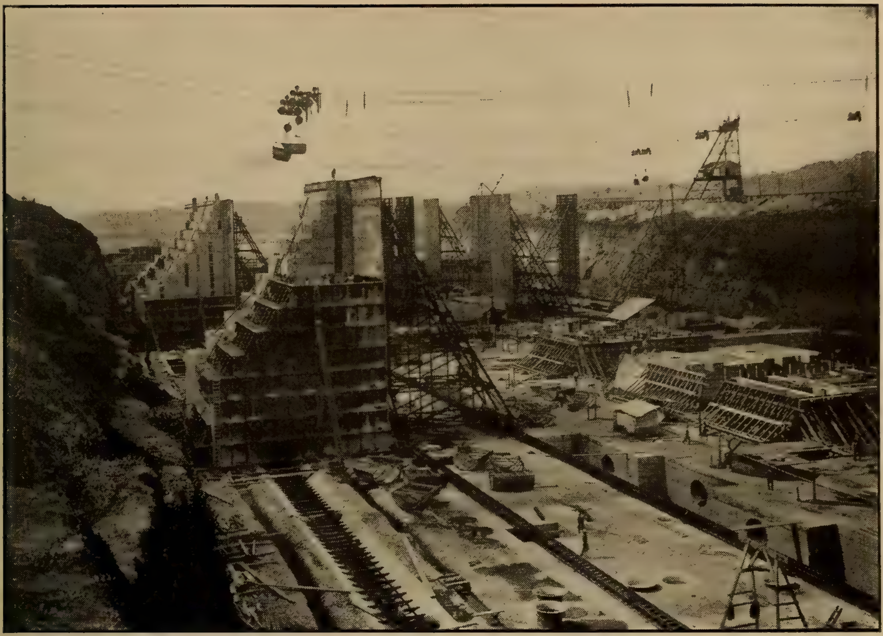
Gatun Lake will cover an area of 164 square miles, with a depth in the ship channel varying from 85 to 45 feet. Throughout the first 16 miles from Gatun the width of the channel will be 1,000 feet, then for 4 miles it will be 800 feet, and for 4 miles more 500 feet, when the entrance to Culebra Cut, at Bas Obispo, will be reached. The water level in the cut will be that of the lake, and the bottom width of the channel will be 300 feet.

The necessity for forming this artificial lake as a part of the waterway was due to the rugged topog-

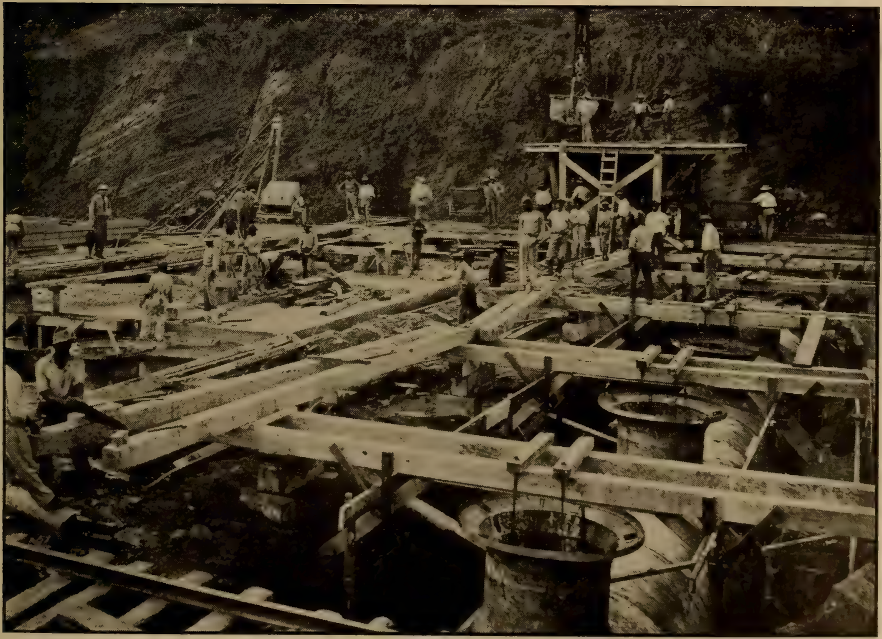


ONE OF THE GREAT LOCKS OF THE GATUN DAM, PANAMA

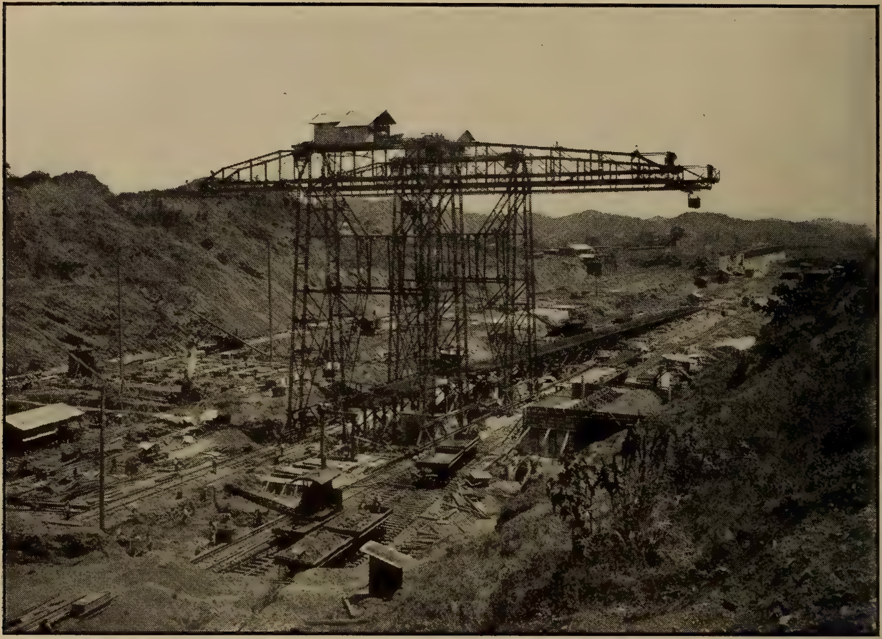
raphy of the isthmus. A sea-level canal along the same route would have entailed such an enormous amount of rock cutting through the hills that the expense would have made the work an impossibility. The idea of a lock, as is well known, was finally adopted after much expert discussion, and the series now under construction planned. This work may be called the climax of engineering skill, for nothing approaching it has ever before been attempted in the height, length, thickness and depth of the massive walls which must be erected to hold a depth of sufficient water for the largest ocean vessel to be lifted by degrees to a height of 85 feet above the lower canal level. As stated, there are twelve locks in the canal, all in duplicate—three pairs in flight at Gatun, with a combined lift of 85 feet; one pair at Pedro Miguel, with a lift of 30 1/3 feet, and two pairs at Miraflores, with a combined lift



LIDGERWOOD CONVEYORS AT THE UPPER GATUN LOCKS, PANAMA



CONCRETE WORK ON PEDRO MIGUEL LOCKS, PANAMA, SHOWING USE OF BLAW COLLAPSIBLE FORMS ON CULVERT CONSTRUCTION



CANTILEVER CONVEYOR ON THE PANAMA CANAL AT PEDRO MIGUEL LOCKS

of 54 2/3 feet at mean tide. The dimensions of all are the same—a usable length of 1,000 feet and a usable width of 110 feet. Each lock will be a chamber, with walls and floor of concrete and water-tight gates at each end.

The side walls are 45 to 50 feet wide at the surface of the floor, are perpendicular on the face, and narrow from a point 24 1/3 feet above the floor until they are 8 feet wide at the top. The middle wall, 60 feet wide approximately, is 81 feet high, and the face is vertical. At a point 42 1/3 feet above the surface of the floor and 15 feet above the top of the middle culvert this wall divides into two parts, leaving a space down the centre much like the letter "U," which is 19 feet wide at the bottom. In this centre space, which is 44 feet wide at the top, is a tunnel divided into three stories, or galleries. The lowest gallery is for drainage, the middle for the wires that carry the electric current to operate the gate and valve machinery, which is installed in the centre wall, and the upper is a passageway for the operators. The lock chambers are filled and emptied through lateral culverts in the floors connecting with main culverts 18 feet in diameter in the walls, the water flowing in and out by gravity.

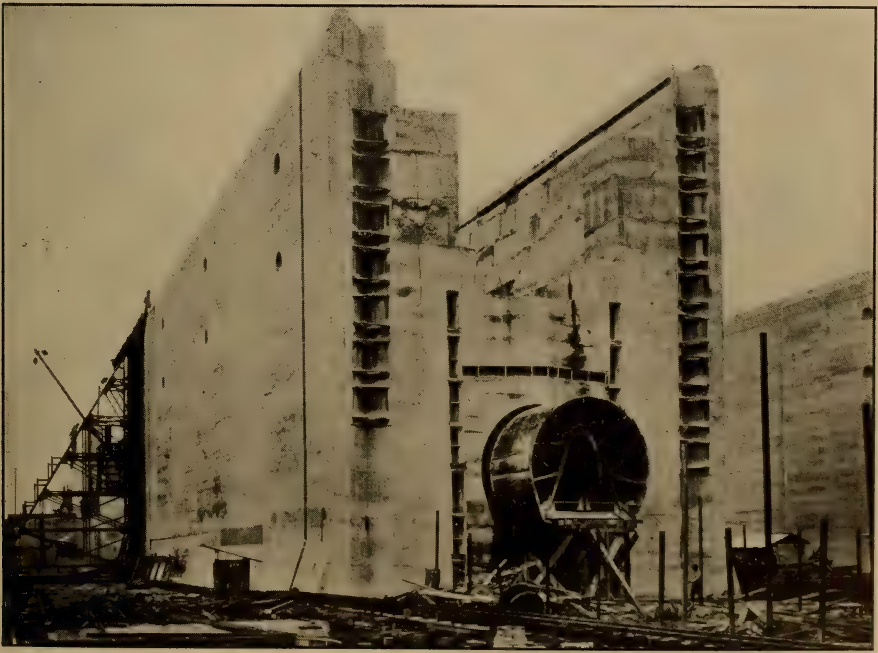
The lock gates will be steel structures 7 feet thick, 65 feet long and from 47 to 82 feet high. They will weigh from 300 to 600 tons each. Ninety-two leaves are required for the entire canal, the total weighing 57,000 tons. Intermediate gates are used in the locks, in order to save water and time, if desired, in locking small vessels through, the gates being so fixed as to divide the locks into chambers 600 and 400 feet long, respectively. In the construction of the locks it is estimated that there were used approximately 4,500,000 cubic yards of concrete, requiring about the same number of barrels of cement. The figures give some idea of the magnitude of what is the greatest engineering feature of the work.

The enormous quantity of concrete

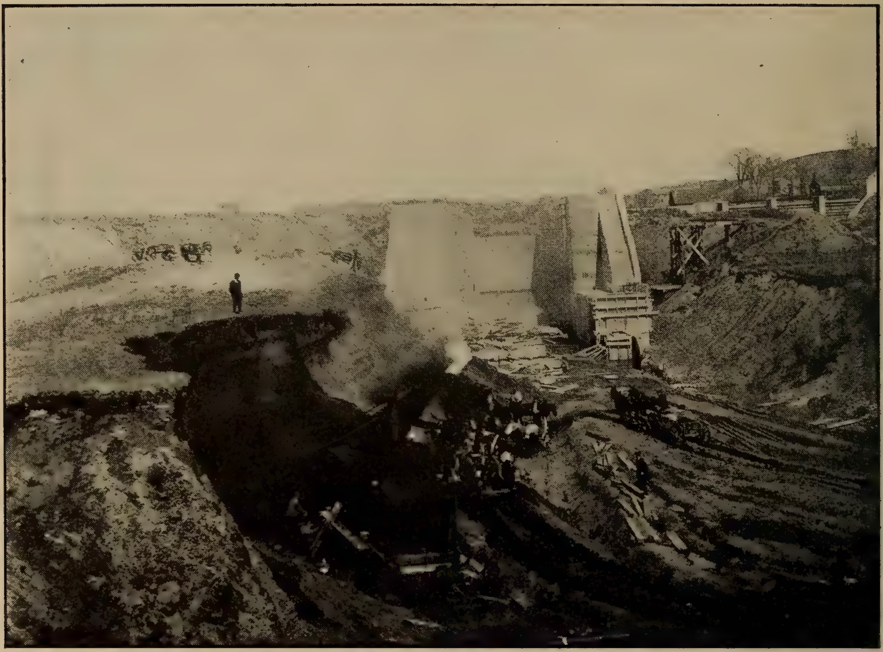
required to mould the locks necessitated special plants on the sites. The materials for cement-making are delivered on cantilever cranes set on towers, which rest on trucks running on tracks parallel to the rock walls. These cranes travel the full length of the locks, and, of course, parallel to them. They are situated outside of the locks. They gather the material from the storage bins, and, with the aid of grab buckets, drop it into the concrete-mixing machines situated in the towers. The inner arms of the cranes are used to transfer the concrete to the outside lock walls and to the smaller or berm cranes, which will, in turn, place it in position on the foundation and centre wall between the locks at points inaccessible to the cantilever cranes. The guaranteed capacity of the plant on the Miraflores locks is about 2,500 cubic yards of concrete per day. That of the cranes at Pedro Miguel is about one-half this, as the structure will be only half as large as the ones at Miraflores.

All of the cranes, cableways, mixers, etc., are electrically operated, and the power plants for furnishing the current are now completed. The forms for the concrete walls are of steel and interchangeable, which allow them to be used on successive stages of the work. The circular forms for the water conduits, machinery chambers, etc., are the rapid, collapsible sheet-steel type. The first part of the concrete work consisted in the laying of a base of concrete 392 feet wide and nearly 4,000 feet long, with a maximum thickness of 20 feet, which forms the floor of the locks. During the construction of this floor care was taken to provide circular transverse conduits with vertical openings through the floor, which lead alternately to opposite side walls, there to connect with the main longitudinal emptying and filling conduits.

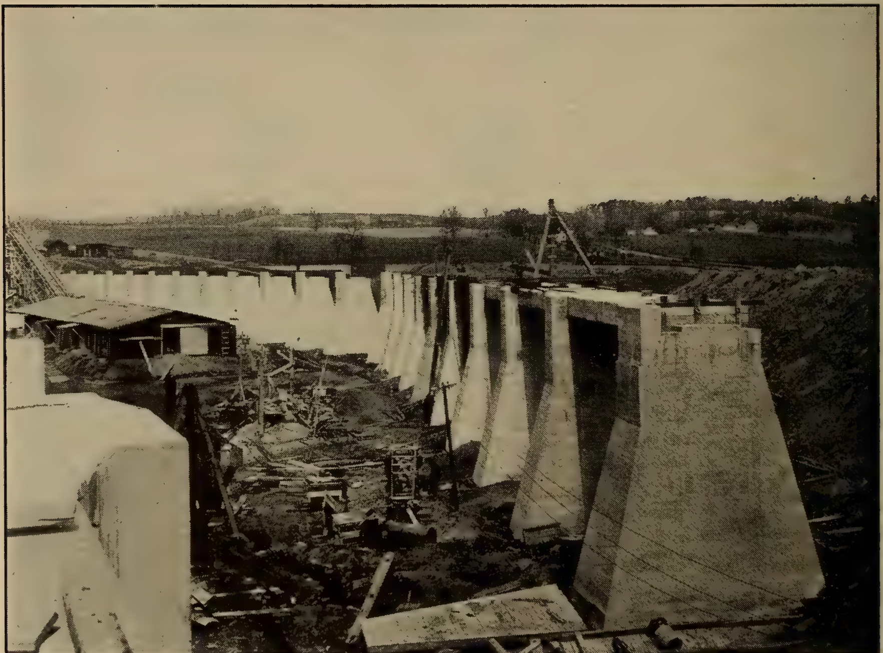
The next task was to erect the side walls. The walls are built in sections, each of which is about 40 feet wide, with a space of about 30



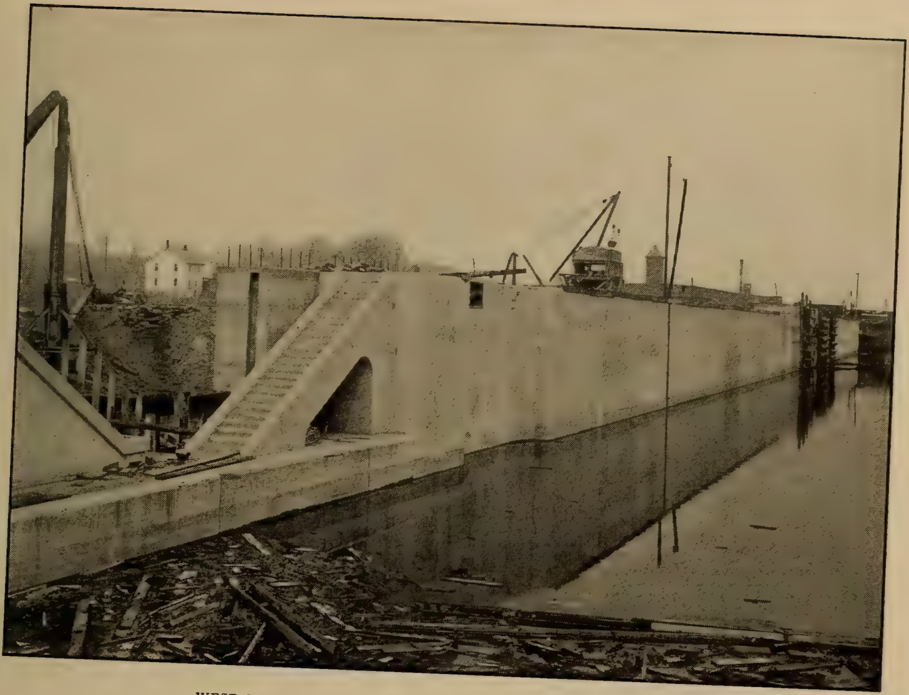
CONCRETE MONOLITHS IN MIDDLE WALL, GATUN LOCKS, PANAMA



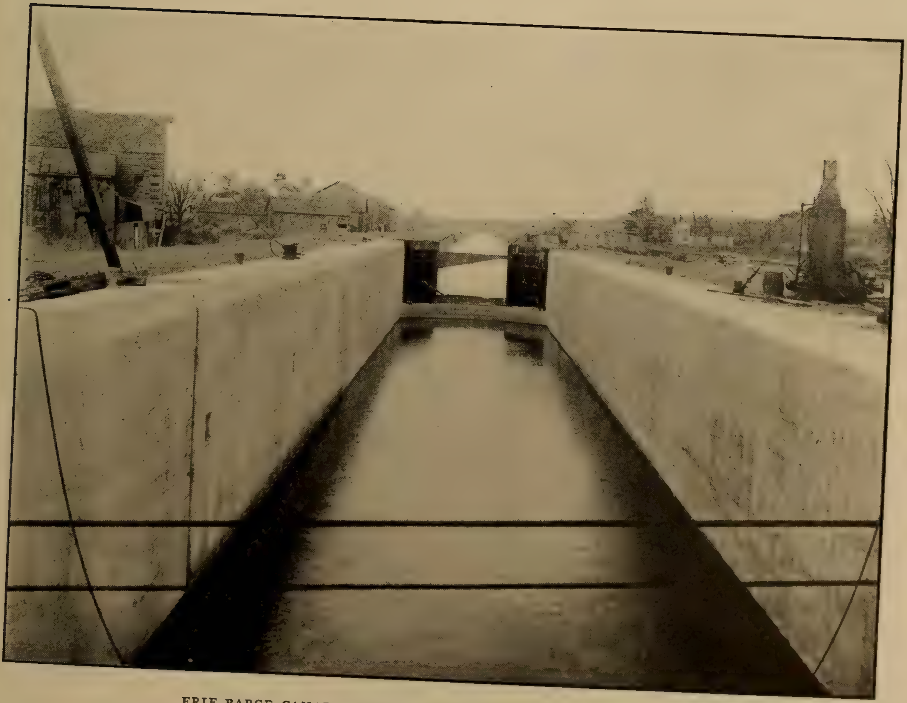
LOCK AND EXCAVATION ON ERIE BARGE CANAL AT WATERFORD



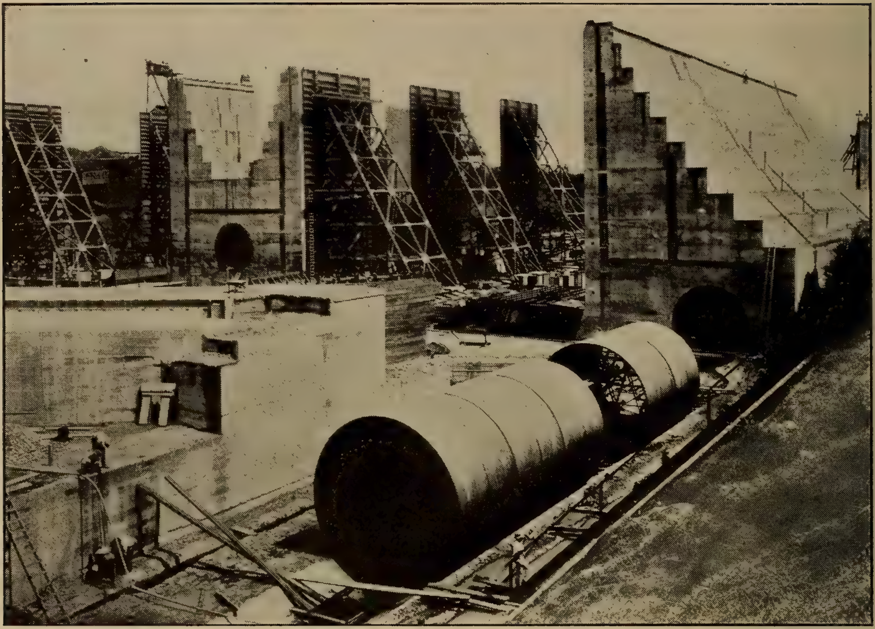
CONCRETE PIER AND BEAM CONSTRUCTION AT WATERFORD, ERIE BARGE CANAL



WEST WALL OF NORTHUMBERLAND LOCK, ERIE BARGE CANAL



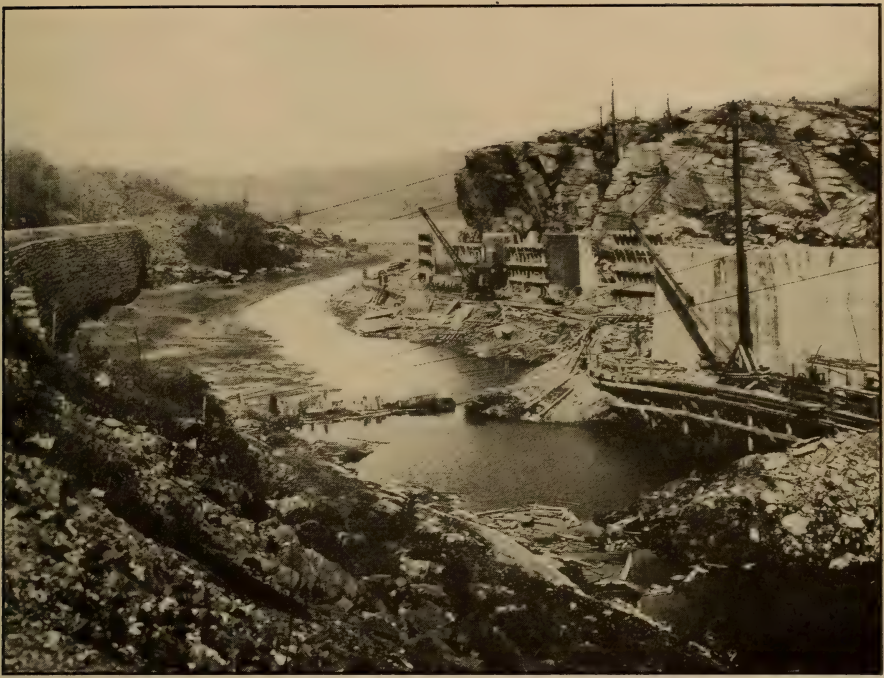
ERIE BARGE CANAL, VIEW OF FORT MILLER LOCK FROM BRIDGE



· CONSTRUCTION WORK ON THE UPPER LOCKS AT GATUN

feet between them. The wall is then completed by filling in the intervening vertical gaps. The forms for the inner vertical face of the walls consist of a series of movable steel towers of a triangular cross-section, to the vertical face of which is riveted a wall of steel plating, stiffened by horizontal channel irons. The towers are carried upon four 4-wheel trucks, two under the front and two under the rear face, which run upon two pairs of rails laid on the floor of the lock and parallel with its longitudinal axis. The rear face of the walls, which is stepped, closes by a series of separate rectangular forms measuring about 6 feet on the vertical and 4 feet on the horizontal face. The ends of each wall section are closed by means of steel plates supported against vertical movable framework. Into the pocket as thus formed the concrete is dumped from the skips of the overhead cable and tamped into place by the labourers until the full 6 feet height corresponding to the height of the rear stepping is completed. The walls are thus carried up three at a time until they have reached their full height.

The total excavation, dry and wet, for the canal as originally planned was estimated at 103,795,000 cubic yards, in addition to the excavation by the French companies. Changes in the plan of the canal made subsequently by order of the President increased the amount to 174,666,594 cubic yards. The Erie Canal, which the State of New York is enlarging, is nearly nine times longer than the Panama, and passes through a region which has also required very expert engineering to solve the problem of excavation and completion. To deepen it from the Great Lakes to tide water at the Hudson means the excavation of 442 miles to a minimum depth of 10 feet and widening the channel for over 100 miles; there will be no less than fifty-four locks, whose lift will vary from 6 feet to a height of 40½ feet, and of these thirty-four will be built along the line of the Erie Canal proper. All of the locks will be 45 feet in width,



VIEW LOOKING WEST FROM LITTLE FALLS, ON THE ERIE BARGE CANAL, SHOWING CONSTRUCTION OF GUIDE WALLS

with a length of from 300 to 310 feet, according to the dimensions of the boats. Throughout the canal the masonry is of concrete. All lock gates are built of steel, and they will be operated by electric motors, the power being generally developed by plants located at the locks, the waterfall generating the electric current. For the control of rivers and streams and the supply of water for filling elevated parts of the canal thirty-five dams will be required, of both the fixed and movable types. The statement of the total amount of excavation and construction to be executed gives an impressive idea of the magnitude of the work:

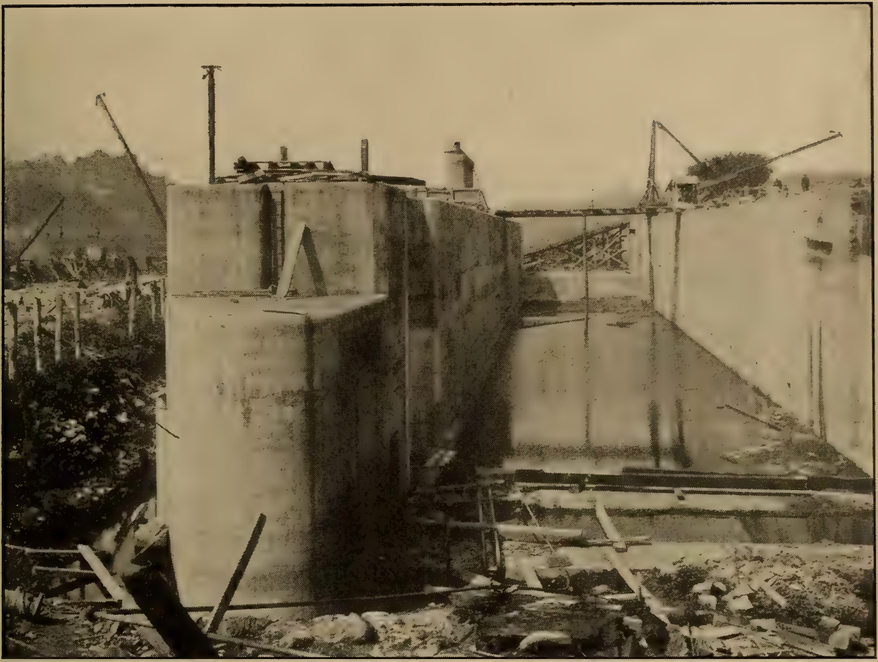
| | Cubic Yards. |
|---|---|
| Dredging | 57,676,700 |
| Earth excavation | 54,989,000 |
| Rock excavation | 10,806,000 |
| Embankment and back filling | 9,454,300 |
| | 132,927,300 |

The enlargement of the Erie Canal to its present dimensions could only be done by the aid of engines and powerful machinery, such as the sand and mud-sucking dredges, for deepening the new channel, material conveyors, rock breakers and power shovels.

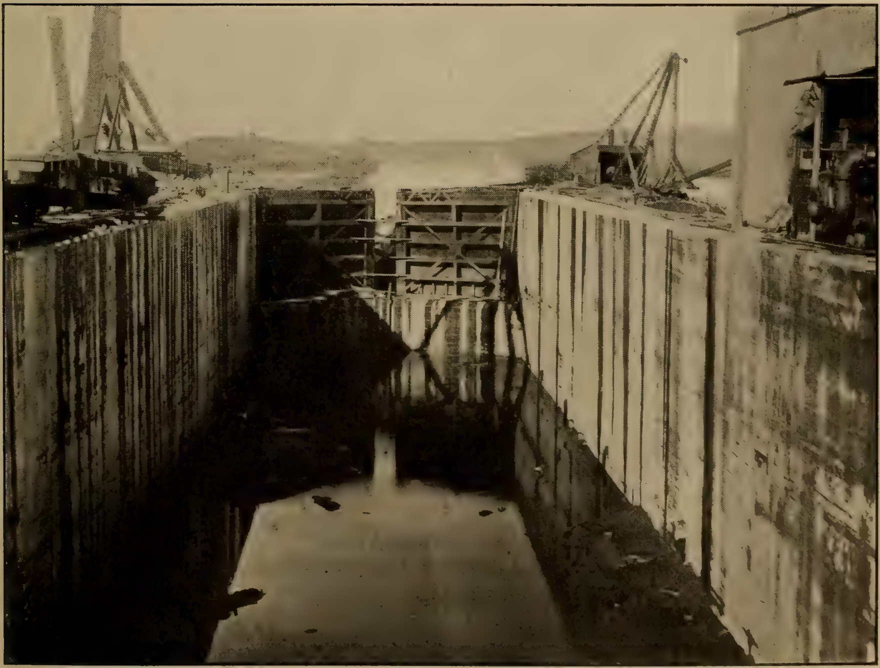
The most interesting part of the reconstruction is the system of locks which is being built at Cohoes to enable the barges to overcome the obstacle presented by the Cohoes Falls. The total difference of level between the Hudson and Mohawk rivers of 121 feet is overcome by three lifts of about 40 feet each, instead of sixteen lifts, which are necessary in the present canal on the westerly side of the river. In this respect the lock system of the Erie is greater in height than that of the Panama, the total lift at this one point being nearly 40 feet higher than the locks connecting with the Gatum section of the Panama. The Erie locks, which are built of concrete and masonry, are 328 feet long between the hollow quoins and 28

CONCRETE RETAINING WALLS ON THE ERIE BARGE CANAL

ERIE BARGE CANAL, LOCK AND LOCK GATES AT COMSTOCK



CONCRETE WORK ON LOCK AT AMSTERDAM, ERIE BARGE CANAL



WEST GATE AND LOCK WALLS AT FORT PLAIN, ERIE BARGE CANAL feet wide in the clear. The water is led from lock to lock by gravity through culverts which are built in the solid masonry, one on each side of each lock and parallel to its axis. These culverts are of the arched type, 5 feet in width and 7 feet in height. The water is led from the culverts into the chamber by means of two cast-iron pipes on each side. These pipes are 2 feet in diameter and 8 feet in length. The water supply to the culverts is controlled by valves at each end of the culvert.

An interesting fact in connection with this project is that the people of New York gave the spending of the hundred millions to their own engineers. There were no boards of consulting experts or councillors. The enlargement of the canal was given to the State officials to do just as the railway president would tell his engineers to build a new extension and expect them to do it right.

The result will show the extent to which such methods may be applied to public works, as contrasted with the excessive officialism which appears in some other parts of the world.

# THE POSSIBILITIES OF THE INTERNAL-COMBUSTION ENGINE APPLIED TO MARINE PROPULSION

### By Percy R. Allen

DURING the four years since Mr. Vennell Coster's paper on "Gas Power on Shipboard" appeared in the special Gas Power Number of CASSIER'S MAGAZINE great attention has been directed to the development of the internal-combustion engine for marine purposes, and the progress that has been made in this direction is, perhaps, greater than is generally realized. For instance, one firm—the Kolomna Company, of Moscow—have supplied twenty-four boats with Diesel motors, aggregating 17,780 horse-power, and out of this total there were seven individual installations of 1,200 horse-power. Another well-known Russian firm—Messrs. Nobel—have supplied seventy-eight ships with Diesel motors, aggregating 16,630 horse-power, but very little has been heard about these experiments in England. However, the success obtained with the *Toiler,* built on the Tyne, the Dutch oil tank boat *Vulcanus* and the gas-driven *Holzapfel I.* have brought before the shipowners in a very striking way the commercial possibilities of internal-combustion engines.

The case for the use of oil or gas for seagoing purposes was most admirably presented by Lord Furness at the last meeting of Messrs. Furness, Withy & Co., the shipowners, and, in stating the reasons why this company had placed an order for a 3,000-ton vessel to be equipped with Diesel engines, he summarized what appeared to be the principal advantages of this system over steam. In the first place, he stated that the weight of fuel required was only one-fifth of that necessary compared with a steam plant of equal power, and that, ton for ton of fuel, less storage space is needed; and as the oil can be carried in double bottoms, a considerable space can be liberated for cargo accommodation, which is the real index of the earning capacity of a vessel. Furthermore, there is a large saving of labour, owing to the absence of boilers, condensers and other accessories of a steam plant, added to which there is the convenience of being able to take on board the necessary fuel by simply pumping it through a pipe instead of having to bunker and trim where coal is used. Although Lord Furness was careful to state that this order was simply to be looked upon as in the nature of an experiment, his opinion on this subject may be regarded as distinctly encouraging, coming, as it does, from a successful commercial man, who is not only the head of large ship-owning concerns, but who is also closely identified in other ways with shipbuilding and marine engine works.

In the report of Lloyd's Register of Shipping for the year ending June, 1911, it was stated that twelve vessels, to be constructed under their supervision, were to be fitted with oil engines. The largest of these will exceed 8,000 tons gross and five of the others will be 4,500 tons gross and upwards; and this does not take into account several large boats that are being built in other countries under different registers.

One of the most encouraging aspects of the situation is the readiness with which builders of internal-combustion engines have shown themselves willing to co-operate with shipbuilders who possess the necessary knowledge of the conditions that must be complied with if this class of engine is to be adapted for seagoing purposes.

The Maschinenfabrik Augsburg-Nürnberg A. G., Germany; Messrs. Carels Frères, of Ghent; Messrs. Sulzer, of Winterthur; Messrs. Schneider, of Creusot; Messrs. Nederlandsche Fabriek van Werktuigen en Spoorweg Materieel, Amsterdam, and Messrs. Burmeister & Wain, of Copenhagen, are some of the firms who have already established relationship with shipbuilders; and in the very interesting paper read by Mr. J. H. Rosenthal at the meeting of the British Association he gives a list of shipbuilders in Great Britain who have taken out licenses from the Maschinenfabrik Augsburg - Nürnberg, in which list is included Mr. Rosenthal's own firm of Messrs. Babcock & Wilcox, the eminent makers of steam boilers.

Owing to the great publicity that has been given to the Diesel engine an impression seems to have got abroad that the gas engine proper is in some way unsuited for ship propulsion, but this is really by no means the case. In either case the running expenses will be lower than with a steam engine, and the choice between oil and gas lies more between the relative space taken up by a gas engine with producer plant and bunkers than by an oil engine with oil tanks; and another consideration is, of course, the market price of coal compared with oil.

Years ago the Gasmotorenfabrik Deutz, of Cologne, installed a number of canal boats with producer plants, and since then the matter has been taken up in England by Messrs. Crossley Bros., Thornycroft & Co., and recently the performances of the *Holzapfel I.* have directed considerable attention to the use of gas engines for seagoing purposes. In most of these installations suction gas producers have been employed, and in the drawings shown in Fig. 1 will be seen the arrangement of a 500 horse-power suction gas plant installed by the Gasmotorenfabrik Deutz on a tugboat on the Rhine. This boat, the *Deutz,* had originally a steam engine of 350 horse-power on board, but was lengthened subsequently to take the twin engines shown in the drawing. It will be noticed that the scrubbers and cleaning plant are placed between the rectangular producer and the engine room proper. The producer is of the type in which the gases pass through the fire zone with the object of destroying the tar. The engines themselves have four cylinders, and when running at their normal speed each give 250 horse-power. They are not themselves directly reversible, but the propellers themselves can be reversed by using one of the methods mentioned later on, and the number of revolutions per minute can be varied between 220 and 90. This tug was put to work in June, 1909, and has principally been employed in towing large barges laden with coal from Ruhrort to Mannheim, which is an exceedingly arduous service. The ordinary brown coal briquettes common in Germany are used for fuel, and, if these are taken to cost 90 marks per 10,000 kilogrammes, the fuel consumption on the round trip amounts to 225 marks. As this boat is towing steadily the whole length of the journey, there is very little manœuvring to do, and the writer understands that the suction plant has answered perfectly.

In Fig. 2 another tug is illustrated which was experimented with on the Scheldt for some considerable time. This also worked with suction gas, and had a four-cylinder engine of 120 horse-power built by the Campbell Gas Engine Company, of Halifax, the same firm also supplying the producer plant. From one point of view this was perfectly successful, but the Scheldt is notoriously a difficult river to navigate, and, as there was so much stopping and

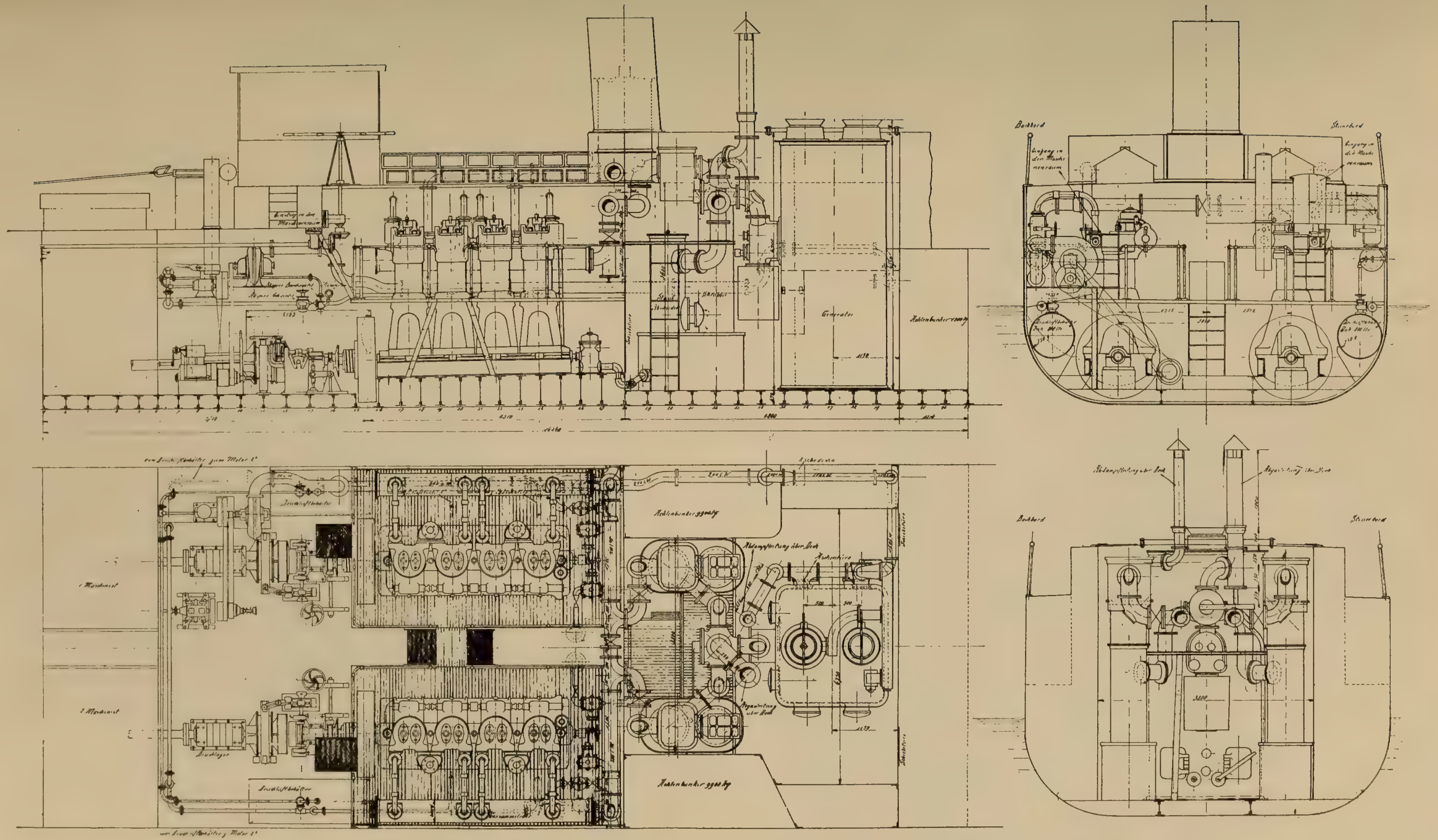


FIG. 1.—THE TUGBOAT DEUTZ, INSTALLED WITH SUCTION GAS PLANT BY THE GAS-MOTORENFABRIK, DEUTZ, GERMANY

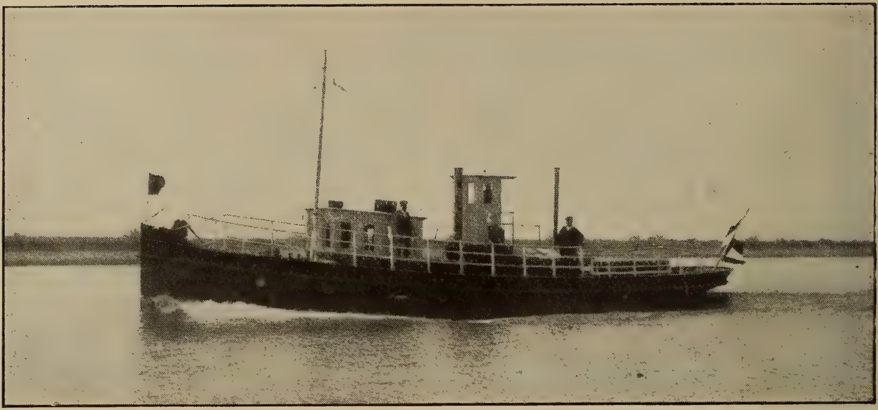


FIG. 2.—TUGBOAT ON THE SCHELDT, INSTALLED WITH GAS ENGINE

starting and manœuvring in the daily routine of this boat, it was ultimately agreed that a suction gas producer was not, perhaps, the most suitable apparatus to use in this particular instance. However, a great deal of valuable experience was gained by this experiment.

It may be mentioned, also, that Messrs. William Beardmore & Co. a few years ago equipped a comparatively large suction gas plant on H. M. S. *Rattler,* and this was given a lengthy test at sea under the command of the Marquis of Graham.

Recently public interest in the use of suction gas at sea has been revived by the performances of *Holzapfel I.* This boat, built by J. T. Eltringham & Co., of South Shields, is not of very large dimensions, being only 120 feet long by 22 feet and 11 feet 6 inches moulded depth, intended to carry 300 tons dead weight on a draught of 10 feet. However, she has already made a number of voyages, having carried 340 tons of granite from Guernsey to London and 300 tons of cement from London to Cork. The general appearance of the boat as she appeared when lying at Blackwall can be seen from Fig. 3, and an illustration of the engines is given in Fig. 4. These are of the high-speed vertical type, built by Messrs. E. S. Hindley, Sons & Co., of Bourton, Dorset, and have six cylinders, 10¾ inches diameter by 10 inches stroke, and give 180 brake-horse-power when running at 450 revolutions per minute. There are several neat points about the construction of the engines, one of them being the corrugation of the outer water-jackets of the cylinders to allow for expansion; but the principal peculiarity about the boat is the adoption of the Fottinger system of hydraulic transmission. This arrangement enables the engines to be kept small and light, as they run at 450 revolutions, while the propeller shaft turns at only 120 revolutions per minute, which is the most efficient speed for the diameter of the screw. The advantages of a system of this kind are referred to later on. The fuel consumption of this boat turned out in practice to be between 25 to 30 cwt. of coal per twenty-four hours, which was under the estimate and about half what a steam engine of similar capacity would have required. The owners are so far satisfied that they are building a larger boat equipped in a similar manner, and say they see no difficulty in going up to 6,000 horsepower with this system.

The question of installing gas engines and producer plants on large vessels was discussed in a paper read by Mr. J. I. Thornycroft before the Institution of Naval Architects in

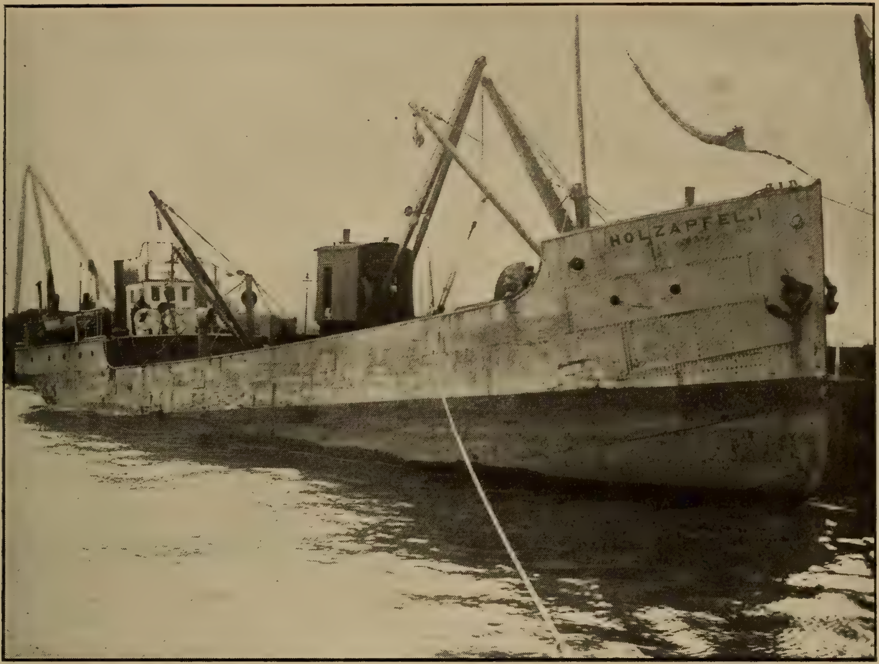


FIG. 3.—HOLZAPFEL I., AT BLACKWELL, BUILT BY MESSRS. J. T. ELTRINGHAM COMPANY, SOUTH SHIELDS

1906, and he showed an interesting comparison between the space required by a gas plant and a steam plant in two similar 7,000-ton cargo steamers, the horse-power in both cases being 2,000; the net result was that with the gas plant a saving of 13,000 cubic feet of cargo space was effected, the gas-driven installation showing also a considerable saving in weight.

It has been proposed from time

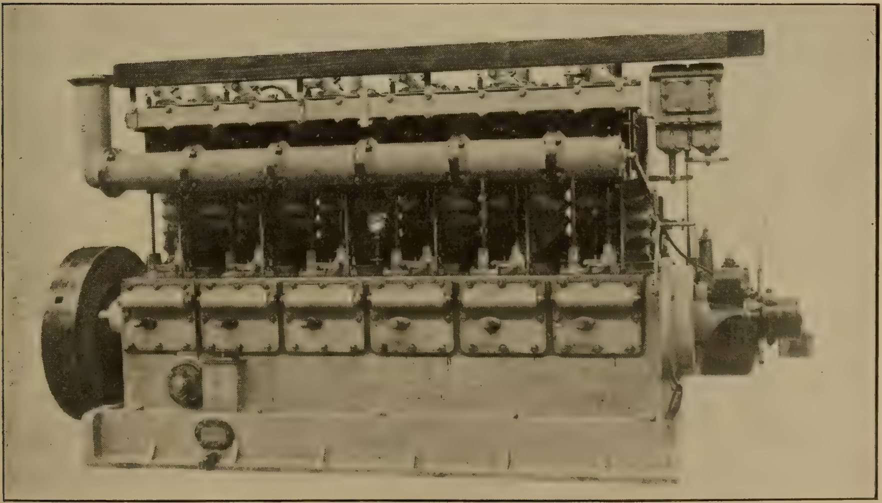


FIG. 4.—GAS ENGINES ON HOLZAPFEL I., INSTALLED BY MESSRS. E. S. HINDLEY & SONS, OF BOURTON, DORSET

to time to fit large vessels with pressure plants having ammonia recovery, after the style of the well-known Mond and Crossley plants on shore; and although this may seem a rather fantastic proposition, there do not appear to be any mechanical difficulties in the way of doing it. No doubt, the arrangement of ventilation with a pressure plant would have to be more elaborate than on a suction plant, and certain inconveniences might arise if it was necessary to carry acid; but it does not follow that the ammonia would be obliged to be recovered in the form of sulphate, and the necessary concentration and evaporation could be obtained from the heat of the exhaust, which would also raise steam to supply the producers. There would, of course, be ample means for cooling the gas, and the necessary absorbers could be easily built into the sides of the hull. If it is assumed that only 85 pounds of ammonia will be recovered per ton of fuel gasified, the value of this sulphate, at £12 per ton, would, in the case of a large cargo boat fully employed, amount to a considerable sum at the end of the year. At the same time, it must be admitted that, up to the present, nobody has shown any particular desire to go closely into the matter.

Coming now to the engines in which liquid fuel is burnt, these may be classified under several headings. One method is according to the class of fuel they burn; for instance, petrol, gasoline, essence, etc., which will, with air, form the necessary mixture by being passed through a carburetor at atmospheric temperature. In the second class come engines using heavier oils, like commercial paraffin. Thirdly, engines of the hot-bulb type, in which the oil has to be vaporized by the action of heat directly before entering the cylinder; and lastly, the engines of the Diesel type, in which oil is injected into the cylinder separately from the air and is ignited directly by the heat generated in the air during the compression stroke. The Diesel engine

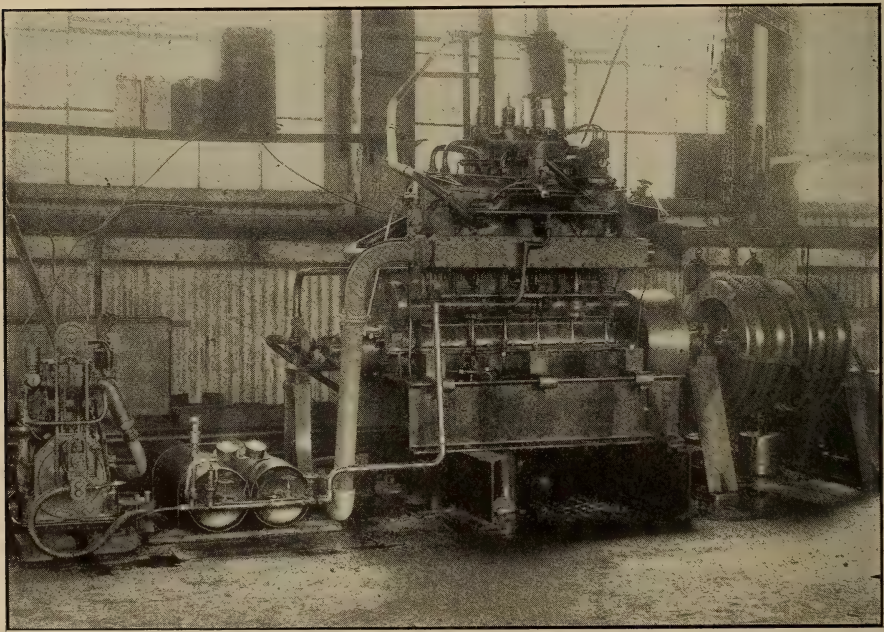


FIG. 5.—FOUR-CYLINDER ENGINE ON THE TEST BED AT MESSRS. JOHN I. THORNYCROFT & CO., LTD., WORKS, CHISWICK, LONDON, W.

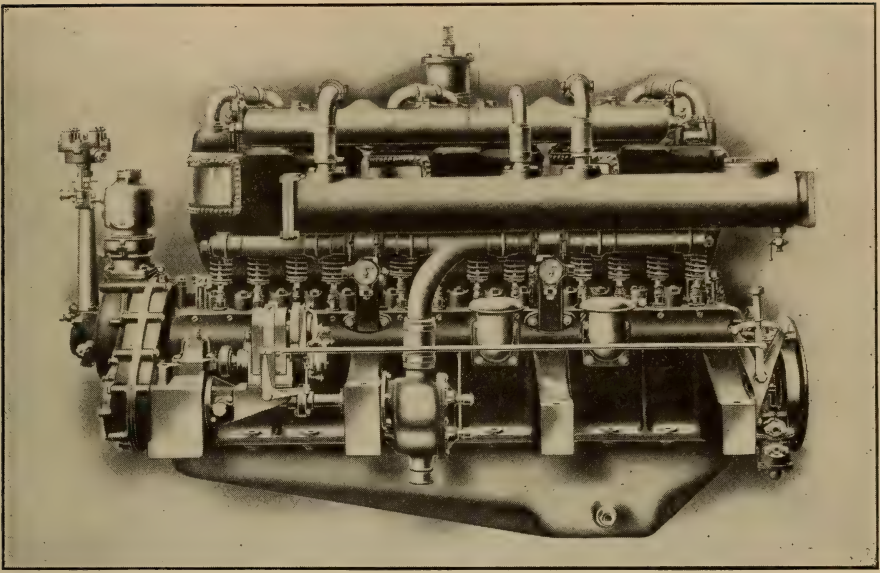


FIG. 6.—SIX-CYLINDER PETROL ENGINE BUILT BY WOLSELEY TOOL & MOTOR CAR COMPANY, LTD., BIRMINGHAM, INSTALLED ON LAUNCHES BUILT BY MESSRS. J. SAMUEL WHITE & CO., LDT., EAST COWES

and the semi-Diesel engine of the hot-bulb type merge into one another. These engines can also be classified in another way, according to whether they operate on the four-stroke cycle or the two-stroke cycle, or whether they are single-acting or double-acting; in fact, the different types could be cross-indexed in several ways.

The operation of the ordinary four-cycle, single-acting engine is so well known that it is unnecessary to describe it here, and up to moderate powers the four-cycle engine applied to propelling a boat very much resembles a four-cycle automobile engine. A representative engine of this kind is given in Fig. 5, which shows a four-cylinder engine on the test bed at Messrs. Thornycroft's works, the absorption dynamometer being shown on the right-hand side. The cylinders are 8 inches by 8 inches, and when running at 700 revolutions per minute the engine will develop 85 brake-horse-power on paraffin and 105 on petrol, and in both cases the consumption is guaranteed to be not more than 0.66 of a pint per brake-horse-power-hour. A carburetor can be used when petrol is the only fuel, but when it is intended to use paraffin a vaporizer with a bypass arrangement is fitted, which permits either petrol or alcohol to be used, as well as paraffin. Control is effected by altering the throttle valve either by hand or through the governor, and spark advance and auxiliary air levers are also fitted to the control board. The ratio between the powers obtained with petrol and paraffin should be noted, as this appears to hold good in most engines of this size. The makers mention they are at present supplying twenty-two petrol motor boats, with engines of substantially the same arrangement, for the Turkish Government. Fig. 6 shows a six-cylinder petrol engine built by the Wolseley Tool & Motor Car Company, Ltd., and supplied to two launches belonging to the Russian Imperial yacht *Polar Star,* the launches themselves being built by the firm of J. Samuel White & Co., of East Cowes. The six cylinders are cast in three pairs, and are 6½ inches in diameter by 7 inches stroke, the engine developing 130 horse-power at 975 revolutions per minute. The reversing gear is of the makers' standard sliding spur gear type. Starting is effected by compressed air at about 95 pounds to the square inch, fed from a reservoir shown on the left-hand side of the illustration. A dual ignition system is used, and special attention has been given to the carburetor. Aluminium is employed for the crank case, and the engine is somewhat remarkable for its light weight per brake-horse-power, as the total weight of the engine, reverse gear, flywheel and control only comes to 19 cwt. for 130 horse-power given out.

A Djinn-engine, built by Messrs. Brazil, Straker & Co., of Bristol, is shown in Fig. 7. This design of engine has not been before the public for very long; in fact, it has only appeared since Mr. Vennell Coster's paper was written. However, quite a number have already been constructed, and the well-known yacht *Fantome,* owned by the Hon. A. E. Guinness, has a twin-screw installation of two heavy Djinn oil engines, each of 135 brake-horse-power. The installation also includes an auxiliary engine-driving dynamo, air compressor and also refrigerating plant. The exhaust gases pass up the foremast and are discharged 60 feet above the deck, having on their way passed through evaporators by which a supply of fresh water is obtained from the sea, the oil engine in this case meeting the most luxurious demands. The particular engine illustrated in Fig. 7 has four cylinders and gives 150 horse-power at 400 revolutions per minute. It may be noticed that the engine is of severely plain outline, but all the parts are extremely accessible, and it will be seen that the air compressor, water and lubricating pumps are all placed at one end, with the control panel and reverse gear close to hand.

The cylinders are cast in pairs and are independently supported on short columns fixed to the base plate, so that the upper part of the crank case has really to be strong enough to be oil-tight. Access to the interior is very easily obtainable by removing the covers. Two systems of ignition are used, the Bosch high-tension magneto and the Lodge battery coil.

Coming now to the Diesel engines for marine purposes, the four-cycle type does not differ much from that used on land, except that they are

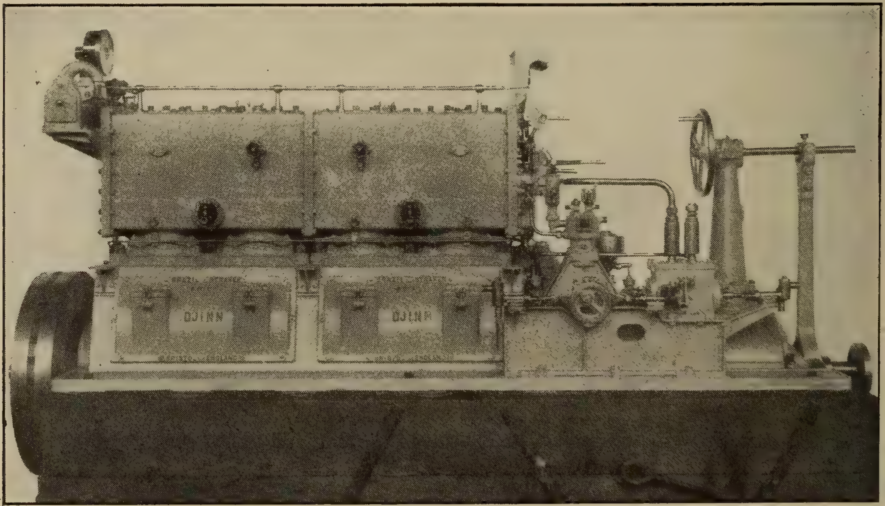


FIG. 7.—A 150-BRAKE HORSE-POWER DJINN ENGINE BUILT BY MESSRS. BRAZIL, STRAKER & CO., LTD., BRISTOL

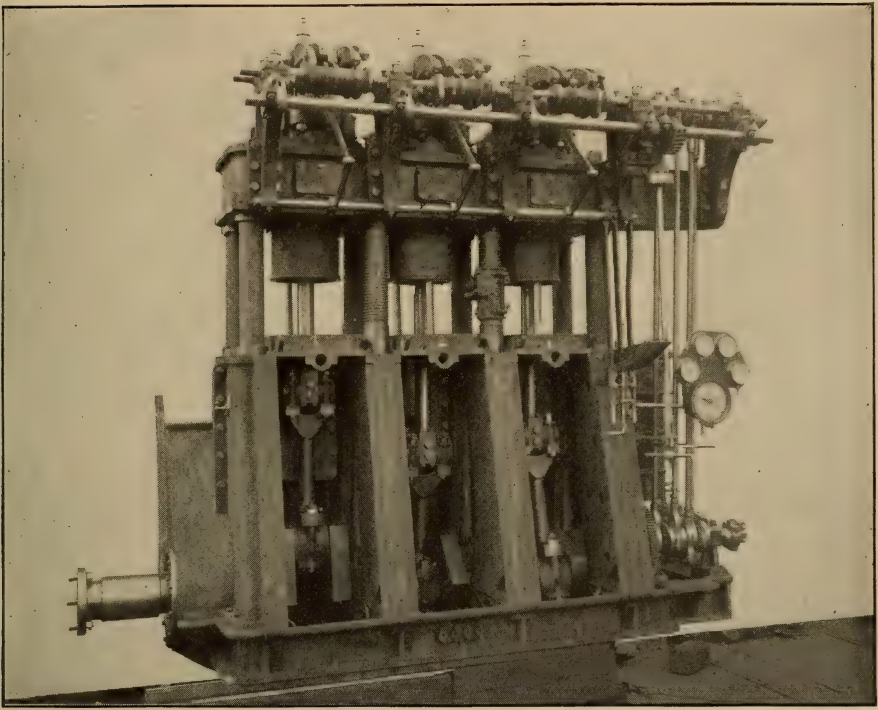


FIG. 8.—DIESEL ENGINE ON THE SEMBILAN. CONSTRUCTED BY NEDERLANDSCHE FABRIEK VAN WERKTUIGEN EN SPOORWEG MATERIEEL, AMSTERDAM

generally arranged to develop their rated power at a greater number of revolutions. The Diesel cycle differs considerably from the Otto cycle, inasmuch as it is a constant-pressure engine, the air alone being compressed and the fuel being injected separately just at the end of the compression stroke. No separate ignition is used in these engines, the heat being generated by the compression of the air itself. As the pressure at the end of the compression stroke rises to nearly 500 pounds per square inch, the oil has to be injected at a superior pressure, and is generally blown in in a pulverized form by means of an air blast fed from a small reservoir charged to a pressure of 750 pounds or thereabouts by means of a compressor attached to the crankshaft of the engine. The supply of fuel oil is forced up to the air atomizer by means of small pumps, which also serve to measure and regulate the supply. The absence of any fuel to burn until the beginning of the working stroke prevents any danger of pre-ignition, and, as the oil particles are burned immediately after their mixture with the air, the combustion is very complete, and the exhaust products are usually free from any smell. Engines can be constructed on this principle having a thermal efficiency as high as 30 per cent. The illustration shown in Fig. 8 represents a marine Diesel engine constructed by the Nederlandsche Fabriek van Werktuigen en Spoorweg Materieel, of Amsterdam, for the *Sembilan*. This has three cylinders, and is of the four-cycle, single-acting, reversible type. There are some interesting points in the design of this engine. It will be seen that the makers have adopted the use of a separate crosshead working in guides in the lower part of the frame, these

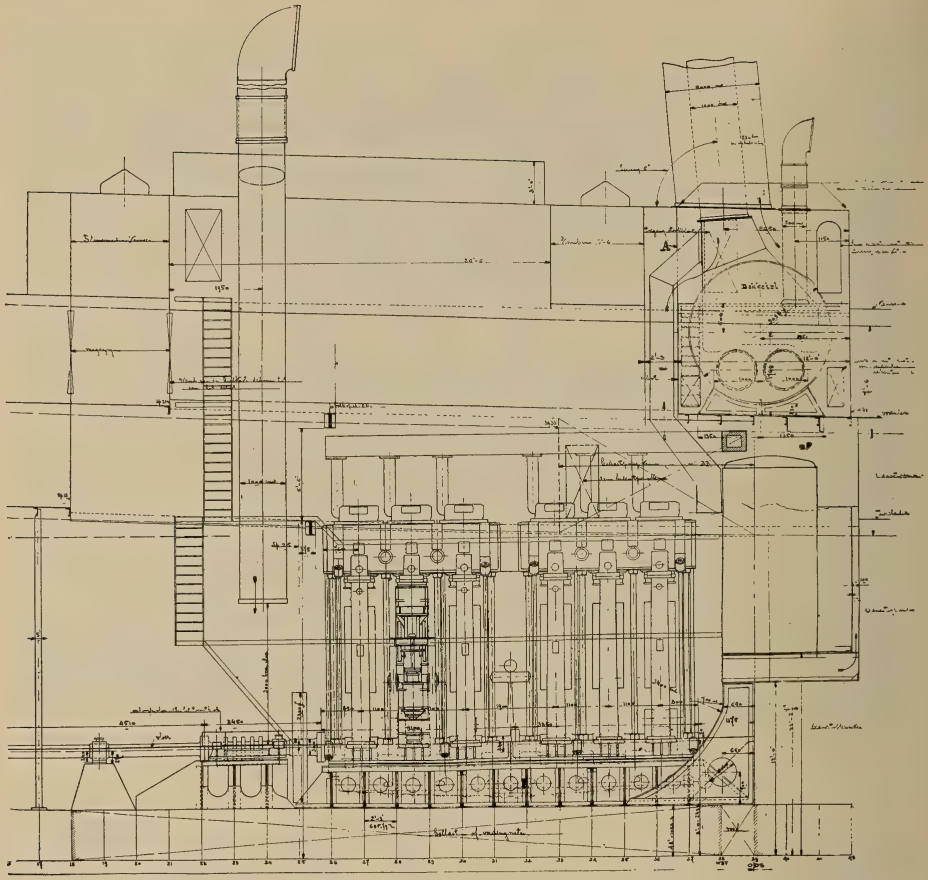


FIG. 9.—SECTION OF ENGINE ROOM OF A TWIN-SCREW TANK STEAMER WITH A 2,200-HORSE-POWER INSTALLATION

guides being entirely separated from the heated portion of the engine above. This involves the use of a piston rod and apparently carrying the cylinders higher from the floor, but whatever objection there may be to this has been minimized by an ingenious arrangement of making the lower part of the cylinders in two halves bolted together, so that when it is wanted to remove the trunk pistons the lower halves of the cylinders are taken off and the piston has only to be dropped until it clears the stationary half of the cylinder, so that a considerable amount of vertical headroom is saved in this direction. It will be seen that the entablature carrying the cylinders is supported on steel columns. This engine gives 200 horse-power at 170 revolutions per minute, and in a general way resembles the engines in the tank ship *Vulcanus,* which was built by the same makers last year. This ship is fitted with a six-cylinder, 500 horse-power engine, and, according to the figures published in *Engineering,* of September 15, shows a remarkably low fuel consumption. On a run of practically twenty-three days from Constantza to Hamburg, a distance of 3,595 sea-miles, the fuel consumption was 42 tons on a displacement of 2,180 tons, which the makers state will not be more than one-fifth of what the coal consumption would have been if the vessel had been equipped with steam power. As a matter of fact, it is somewhat interesting to learn that, so far, apparently all the vessels equipped with internal-combustion engines have fulfilled the expectations that have been formed as regards economy of fuel. The builders of the *Vulcanus* have now in hand a twin-screw installation for a motor tank vessel belonging to the Société Anonyme d'Armement d'Industrie et de Commerce of Antwerp, with two pairs of engines, each developing 1,100 horse-power, and also a tank vessel for the Anglo-Saxon Petroleum Company, with one set of engines. In the larger boat the deck machinery is worked from a steam boiler heated by the exhaust gases. A longitudinal section through the engine room of the 2,200 horse-power installation is given in Fig. 9.

So far, these Amsterdam builders seem to prefer to stick to the four-cycle type, and make the rather quaint remark that before two-cycle engines of a large size are introduced the four-cycle type should be allowed to get through its period of seasickness. However, be that as it may, increasing attention is certainly being given to the two-cycle engine for ship work, one of the principal reasons being that the use of a central exhaust port very much simplifies the reversing arrangements, and, at the same time, weight for weight, the output of the engine is increased by probably about 50 to 60 per cent. Against this are the disadvantages of the complications of the scavenging arrangements, and it is generally assumed that a two-cycle engine is not so economical as regards fuel as one of the four-cycle type.

The writer, however, has never been able to endorse this statement thoroughly, even after numerous tests founded on the analyses of the exhaust gases. Apparently much depends upon whether the scavenging is with clean air, as would certainly be done on a large engine, or whether it is done with mixture.

In a four-cycle engine the products of combustion are expelled by the piston sweeping the burnt gases out of the cylinder on the return stroke following the explosion. In a two-cycle, single-acting engine the products of combustion escape through a large port or a number of holes in the walls of the cylinder, which are uncovered by the piston at the end of the stroke. If the two-cycle engine is made double-acting, these exhaust ports are placed approximately in the centre of the cylinder; but as the piston is made proportionately long, the ports serve both ends of the cylinder in turn, and the action is really the same in both instances. As the action of the piston does nothing in the way of effecting a mechanical removal of the burnt gases, the operation of clearing the cylinders and introducing another charge has to be effected in some other way. In small engines this is effected by what is termed "crank-case compression," and Fig. 10, which represents a section of the Caille two-cycle engine—an American design, which may be regarded as fairly representative of this type—enables the operation to be

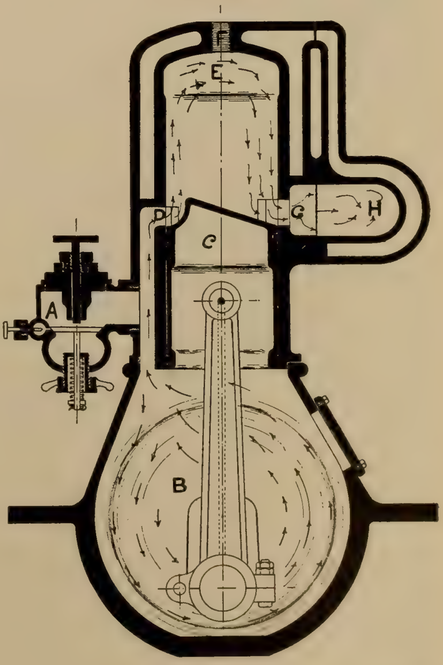


FIG. 10.—SECTION OF CAILLE TWO-CYCLE ENGINE

followed. The piston *C* is shown at the lower end of its stroke, with the inlet port *D* open and the exhaust port *G* open. When the piston *C* travels upwards a vacuum is created in the crank case *B,* allowing the air to pass into it. As this air passes over the carburetor or vaporizer *A,* it carries with it a certain amount of fuel, which can be regulated by a needle valve. When the piston *C* reaches the top of its stroke the check valve in the transfer port closes, cutting off communication with the crank case. On the downstroke of the piston *C* the mixture is compressed to about 5 pounds pressure, and as the piston reaches the end of its downward stroke it opens the port *D,* allowing the mixture to expand into the cylinder. Then as the piston moves up it closes the port *D,* and the mixture confined in the cylinder is compressed to about 45 pounds in the firing chamber *E,* and is in due course fired by the sparking plug screwed into the opening *F.* This causes combustion or explosion, driving the piston downwards until it opens the exhaust port *G,* allowing the burnt gases to escape through the exhaust pipe *H* and permitting fresh mixture to enter. This operation is repeated with each revolution of the flywheel, giving an impulse each complete revolution. The peculiar curved form of the piston on the inlet side is intended to direct the incoming mixture so that it sweeps up towards the cylinder head and drives out the burnt gases without rushing straight across to the exhaust port. For small engines this arrangement, although it cannot be considered a positive scavenge, and a certain amount of mixture can, and probably does, escape through the exhaust port, on the whole seems to answer very well, and a large number of these engines are in use, particularly in America. In a two-cycle Diesel engine the air for the scavenging charge is obtained from an independent source of supply. In land engines a small low-pressure pump driven from the main crankshaft is frequently used, but for marine engines an arrangement frequently adopted is to make the trunk piston in two diameters, the smaller and upper portion of it fitting in the working cylinder, while the larger diameter below gives the necessary volume of compressed air, and thus each cylinder contains its own air compressor. The various operations taking place during the cycle are clearly shown in the diagrams given in Fig. 11, which is reproduced by the kind permission of Mr. J. H. Rosenthal from Babcock - Wilcox brochure on "Nürnberg Oil Engines for Marine Purposes." It will be seen that immediately the exhaust port is covered by the upward motion of the piston the air valve admitting the scavenging air closes, and the high compression of what air is in the cylinder at the moment takes place in just the same way as in the four-cycle Diesel engine. When the two-cycle Diesel engines are built double-acting this arrangement could not be conveniently employed, and the scavenging pumps have to be worked by some prolongation of the crankshaft or by independent motors. The actual arrangement does not matter, as all that is wanted is a plentiful supply of air at from 3 to 6 pounds to the square inch. The air supply for the scavenging charge must not be confounded with the high-pressure air supply required for the injection of the oil. This is in nearly all cases obtained by a small two-stage compressor driven off the crankshaft, very frequently of the plunger type, with water-cooling arrangement between the two diameters of the piston; but during the last two or three years the Reavell compressor has been extensively adopted for this purpose. An illustration, Fig. 12, shows the standard type of land machine adapted for marine purposes. It will be seen that there is an intercooler between each stage and that the low-pressure cylinders are fitted with both suction and delivery valves, so as to make the machine reversible.

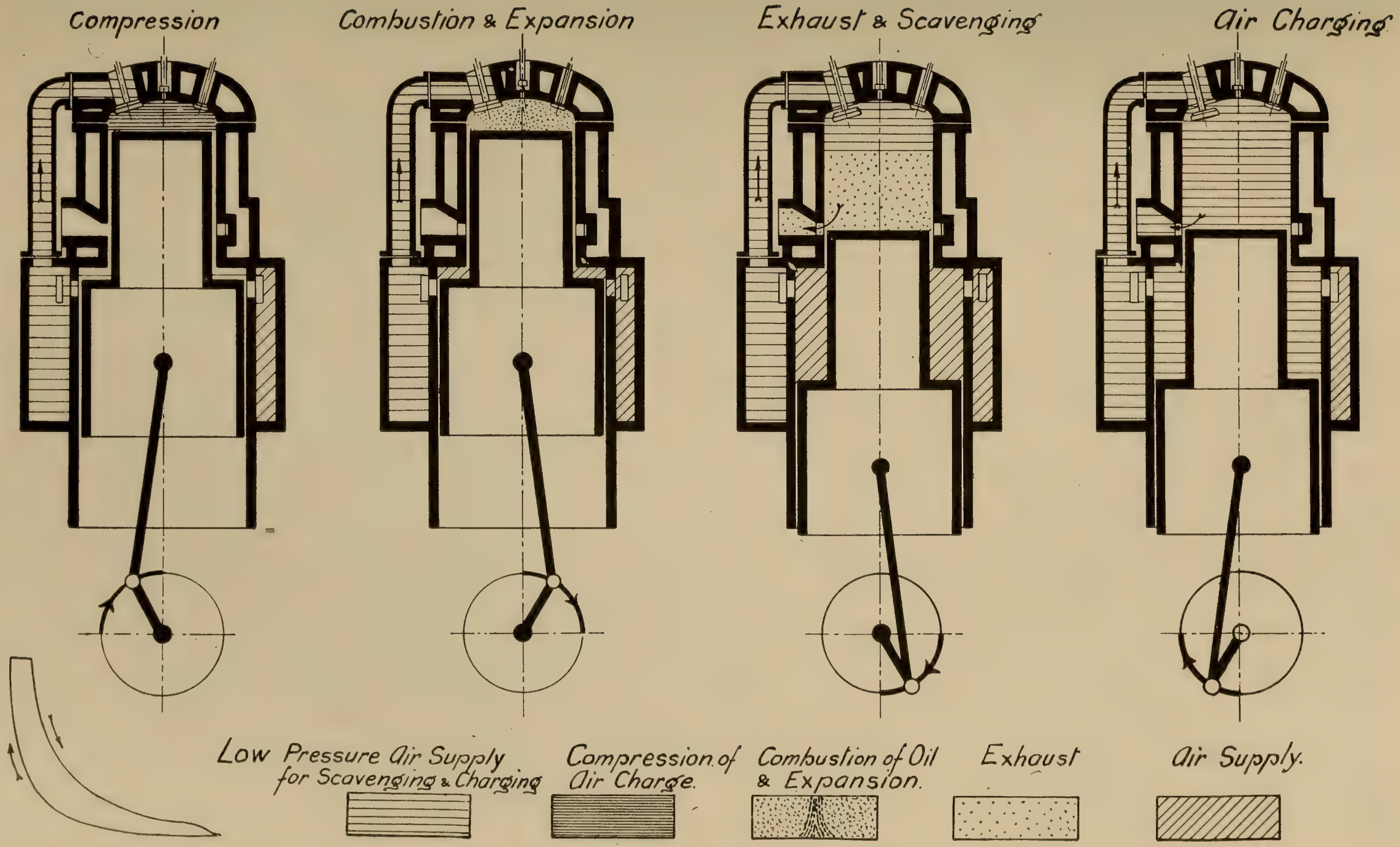

Compression
Combustion & Expansion
Exhaust & Scavenging
Air Charging
Low Pressure Air Supply for Scavenging & Charging
Compression of Air Charge.
Combustion of Oil & Expansion.
Exhaust
Air Supply.

FIG. 11.—DIAGRAM OF NURNBERG TWO-CYCLE OIL ENGINES FOR MARINE PURPOSES

Reproduced by permission of Mr. J. H. Rosenthal, of Messrs. Babcock & Wilcox, Ltd., London.

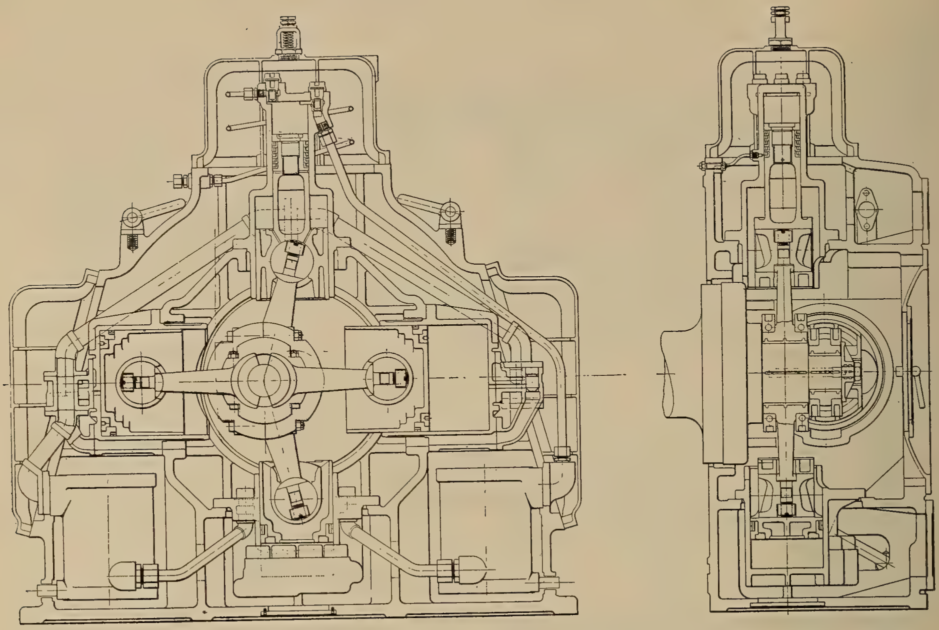


FIG. 12.—AIR COMPRESSOR, BUILT BY MESSRS. REAVEL & CO., LTD., IPSWICH

Reference should certainly be made to the prominent part taken by Messrs. Sulzer Bros., of Winterthur, in applying the Diesel engine to marine purposes. The writer believes that the first directly reversible Diesel engine was the one they exhibited at the Milan Exhibition in 1906, and which was afterwards installed on the *Venoge,* a barge plying on the Lake of Geneva.

Messrs. Sulzers have since then rapidly developed the single-acting, two-cycle marine engine, and have now obtained a capacity of 2,000 horse-power in one cylinder. The standard design of their four-cylinder, two-cycle, single-acting engine is shown in Fig. 13, the two-stage, high-pressure pump being at the extreme end combined with a low-pressure scavenging pump adjacent to the working cylinders, and in the general view shown in Fig. 14 *C* represents the air duct which conveys the scavenging charge to the valves *D.* The horizontal camshaft *E* is driven by a vertical shaft geared to the crankshaft. The fuel oil passes through the regulating valve *J* and the pipe *K* to the fuel pumps *LL* and enters the cylinders by the valves *NN,* while the air for spraying is carried through the pipe *P.* The cooling water circulation is effected by a pump *Q,* which is combined with a Lentz pump. Starting and reversing take place by compressed air conveyed through the pipe *O.* The various changes in the combinations of the valve gearing incidental to the operations of stopping, starting and reversing are all effected by the manipulation of the hand wheel *G.* Altogether, this engine may be taken as a very good example of the up-to-date practice in the single-acting, two-cycle type. Fig. 15 shows a diagrammatic view of the piston in three different positions, *C* showing the piston at the end of the working stroke with the exhaust ports uncovered and the scavenging air valves open, allowing the air to rush in and sweep out the cylinder. *A* shows the piston on the top dead centre with the needle valve open and the oil being sprayed in and spontaneously ignited, while *B* shows the piston almost at the end

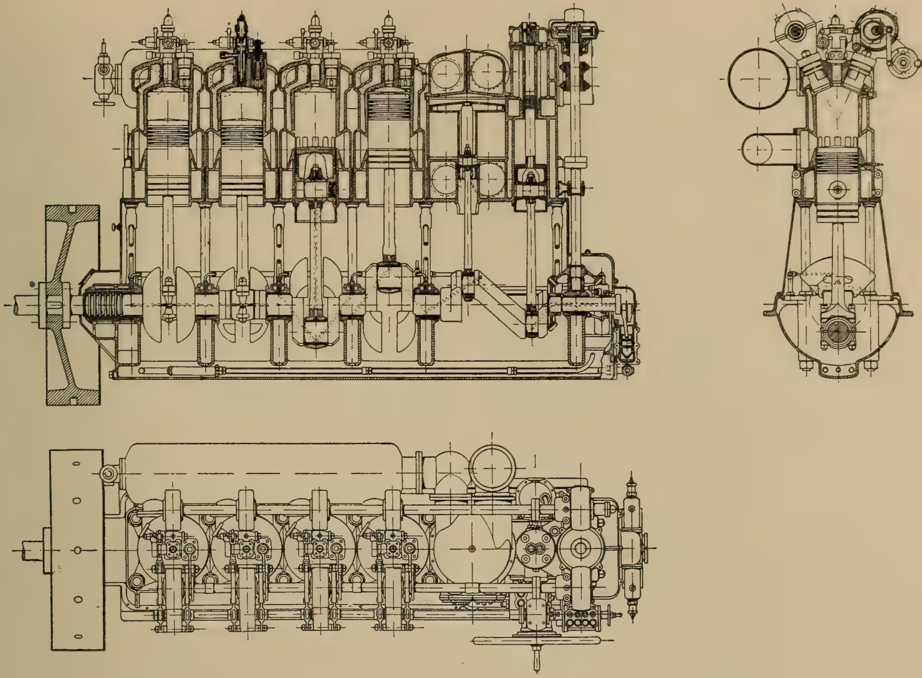


FIG. 13.—SECTION OF TWO-CYCLE MARINE ENGINE BUILT BY MESSRS. SULZER BROS., WINTERTHUR, SWITZERLAND

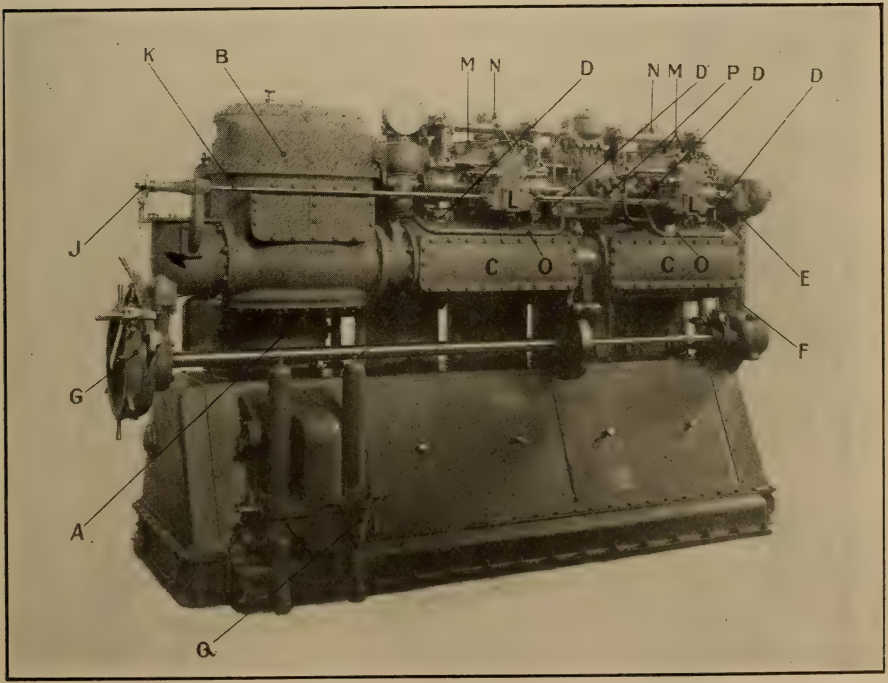


FIG. 14.—GENERAL VIEW OF TWO-CYCLE MARINE ENGINE BUILT BY MESSRS. SULZER BROS., WINTERTHUR

of the working or expansion stroke just prior to the opening of the exhaust ports. Fig. 16 shows a diagram comparing the turning moment of a four-cylinder, four-stroke cycle and a four-stroke, two-cycle engine of equal power, showing that a much smaller flywheel is necessary with the two-cycle engine.

Fig. 17 is a picture of the launch of the *Romagne,* which was built last year for the Ravenna-Triest-Fiume Line, and which is fitted with a pair of twin-screw, reversible, two-cycle Diesel engines coupled direct to the propeller shafts. These two engines together develop 800 horse-power. There are a number of interesting details about these engines which cannot well be described here, but they all conduce to a good efficiency, and it has been ascertained that with an engine giving 500 horse-power as its normal load the fuel consumption is only increased 14 per cent. when the load is reduced to one-quarter—namely, to 100 horse-power.

An illustration of the *Toiler,* built on the Tyne by Messrs. Swan, Hunter & Wigham Richardson, Ltd., is given in Fig. 18. This boat was built for special service on the Canadian canals and lakes and is 280 feet long by 42½ feet beam by 19 feet depth, moulded. On her trial voyage to Calais the boat carried a total deadweight of 2,700 tons on a mean draught of 14 feet. Owing to the conditions of traffic on the Canadian canals the engines were of comparatively small power compared to the size of the boat. The combined capacity of the two sets is only about 400 indicated horse-power, and the fact that under these conditions the *Toiler* was the first commercial vessel fitted with internal-combustion engines to cross the Atlantic will always remain as a remarkable achievement. The engines themselves are of the two-cycle, reversible type, built by the Diesel Motor Company, of Stockholm, and fitted to the boat by the builders at their Neptune works. It was ascertained on the trial trips that the consumption of oil at full speed did not exceed 1.7 tons per day of fuel oil of 18,000 B. T. U.'s calorific value, whereas with the steam engines of equal power the consumption of coal would have been not less than 8 tons per day. Incidentally, the use of oil engines on this vessel considerably increases the cargo-carrying capacity, and the staff required in the engine room was considerably smaller than would have been the case if steam

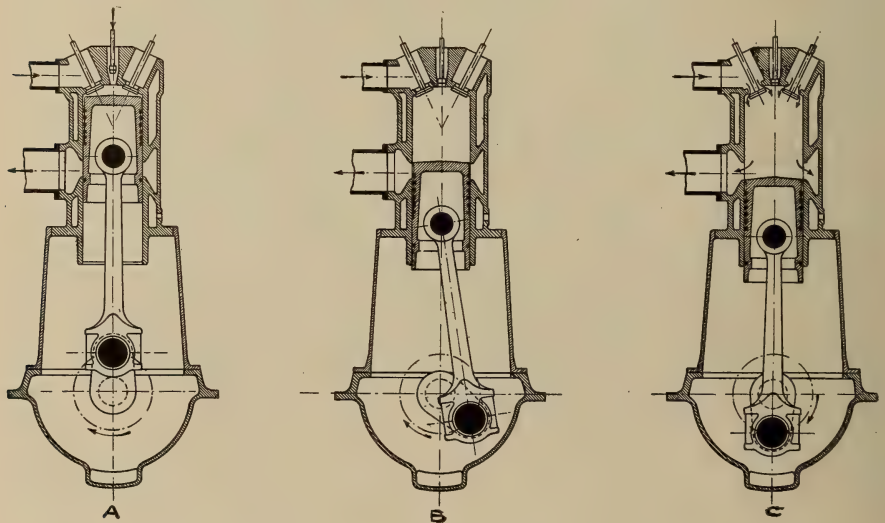


FIG. 15.—DIAGRAM OF ENGINE SHOWING THREE POSITIONS OF PISTON. MESSRS. SULZER BROS.

had been used. That this installation is regarded as a practical success is borne out by the fact that the builders are constructing, at their Neptune works, Newcastle, further vessels, and are constructing the engines themselves.

Another form of two-cycle marine engine which is now being constructed for a 6,500 horse-power boat on the Continent is illustrated in Fig. 19. This is being built according to the design of Prof. Junker, of Aachen, who has been associated with the development of the Oechelhaüser engine from the commencement, and it will be at once recognized as belonging to the so-called two-stroke Oechelhaüser type. Two open-ended cylinders are placed one above the other, giving an impulse to the crank with each stroke the same way as in an ordinary steam engine. This construction necessitates a three-throw crank to each unit, but of late years the crank difficulty with this class of engine seems to have been quite got over, and the most serious criticism to make about the design is that the upper cylinders must of necessity be a very considerable height above the crankshaft. On the other hand, there is the advantage of the long stroke and small-diameter, open-ended cylinders and the absence of all valves in the cylinders themselves. It is premature to say much about this yet, but the results obtained will certainly be watched with much interest.

One somewhat unexpected result of the progress that has been made in marine oil engines is that they will probably prolong considerably the existence of the large sailing vessel. As a cheap method of conveying freight long distances the large three or four-masted steel sailing ship still holds its own, particularly where it sails under the French flag and is assisted by substantial bounties. The grain trade between the Pacific Coast and Europe is still largely dependent on sailing ships, but the great disadvantage attending their

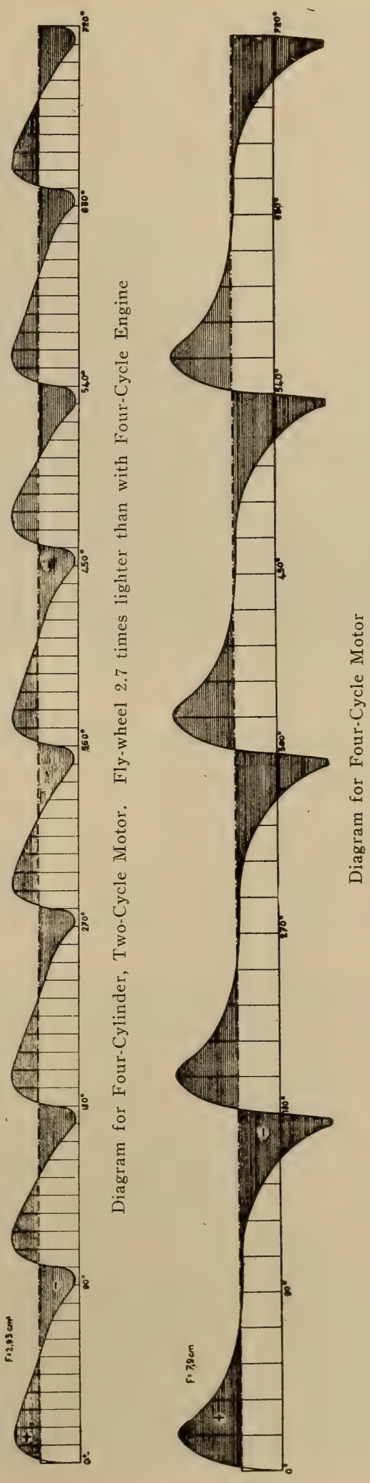


Diagram for Four-Cylinder, Two-Cycle Motor. Fly-wheel 2.7 times lighter than with Four-Cycle Engine

Diagram for Four-Cycle Motor

FIG. 16.—COMPARISON OF TURNING MOMENTS

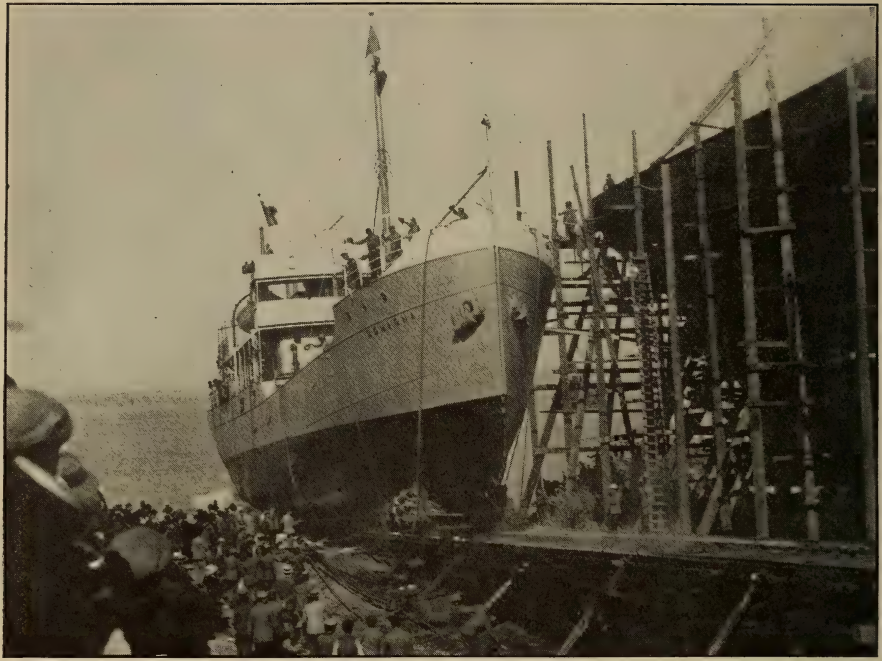


FIG. 17.—LAUNCH OF THE ROMAGNA, WHICH IS FITTED WITH A TWO-CYCLE DIESEL ENGINE

employment has always been their liability to become becalmed for days and sometimes weeks, and their absence of reserve power at a critical moment. The advent of the large internal-combustion engine has put quite a different complexion on the matter, and it is now possible for a sailing ship coming round Cape Horn to regard the absence of winds almost with equanimity, as the auxiliary power can be put into action and ensure a progress of from perhaps 4 miles per hour until the zone of inaction has been passed, when the vessel can again revert to her

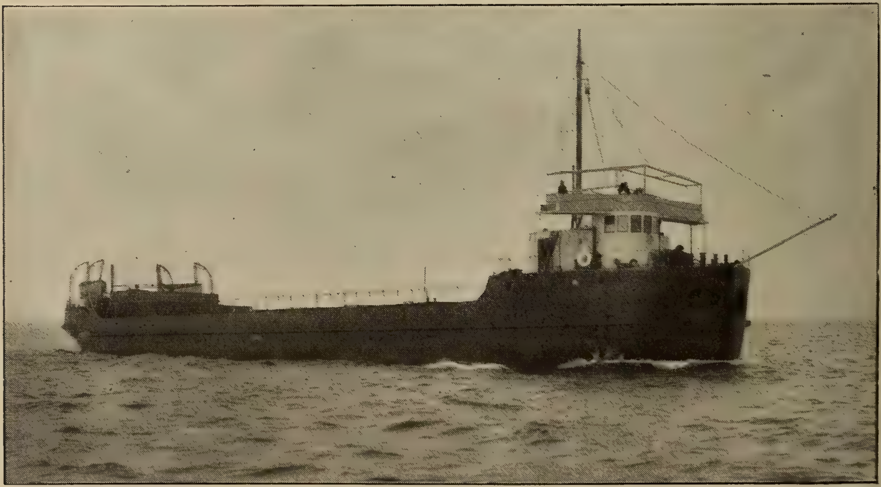


FIG. 18.—THE TOILER, FITTED WITH ENGINES BUILT BY THE DIESEL MOTOR COMPANY, STOCKHOLM BUILT BY SWAN, HUNTER & WIGHAM RICHARDSON, LTD.

sails. A large four-masted sailing vessel, the *Quevilly,* belonging to a firm of shipowners at Le Havre, is shown in Fig. 20. This ship is regularly engaged in the transatlantic trade, and is fitted with twin screws driven by two auxiliary Nürnberg engines of 300 horse-power each, and at the present moment a number of other sailing vessels are being fitted out in a similar way.

It is, naturally, somewhat difficult to obtain any reliable information as to what is being done with internal-combustion engines in the various navies of Europe. It is, of course, well known that oil engines have been used for many years in the navy for auxiliary purposes, such as electric lighting, and they have been used to a considerable extent in the smaller launches and pinnaces carried by the larger vessels. They have found a distinct field for their use in submarines, and there is every reason to believe that the various naval constructors are considering their employment on cruisers and destroyers, if not actually on first-class battleships. A large single-acting, two-cycle Diesel engine for the German Navy is shown in Fig. 21, this being one of several built for the German Navy at Messrs. Krupp's works at Kielgarten. The output of this engine is about 1,000 horse-power, and it will be seen to consist of six working cylinders arranged right and left from the centre in two groups of three each. The large low-pressure compressors for the scavenging charge are shown at each end of the engine, and the high-pressure pumps for the pulverizing air are situated at the centre. The horizontal cam-shaft carrying the valves also extends right and left from the centre of the engine, and the control levers are all concentrated there.

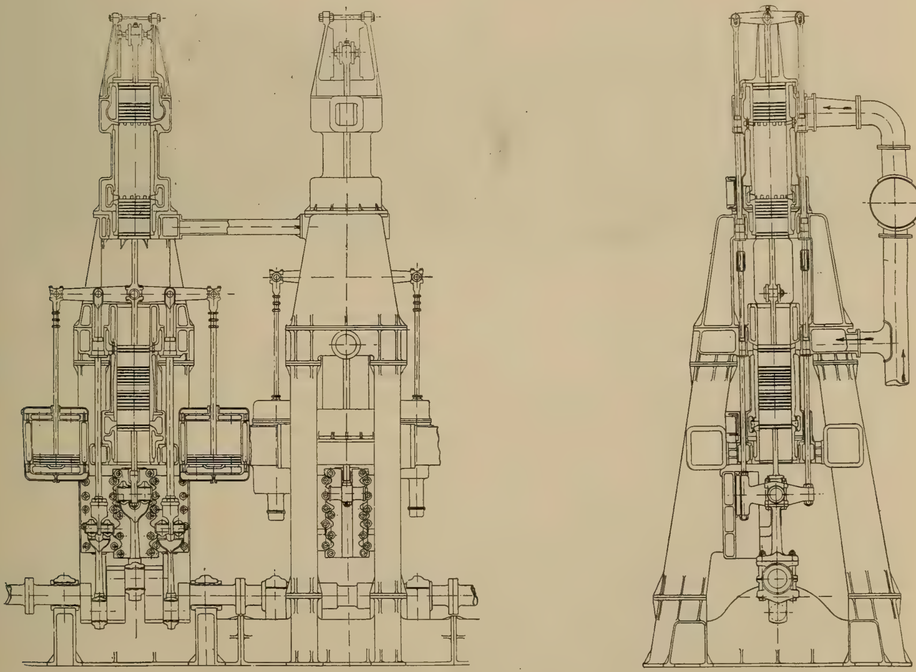


FIG. 19.—TWO-CYCLE MARINE ENGINE DESIGNED BY PROF. JUNKER

The peculiar conditions imposed upon engines for submarine boats have led to the development of a distinct design for the purpose. The space available in the submarine has to be

FIG. 20.—THE QUEVILLY, FITTED WITH TWIN SCREWS DRIVEN BY NURNBERG ENGINES

limited and the highest possible power has got to be put into the smallest compass with the minimum of weight. The majority of these boats are now fitted with engines of the Diesel type, to enable heavy oils having a high flash point to be used, as any possibility of fire or explosion on a submarine would be a very serious matter. However, paraffin as a fuel is still used in some submarines, and a very interesting set of engines built by Messrs. Thornycroft for the Royal Italian Navy are shown in Fig. 22. These were installed in twin-screw boats, and each engine consists of two units of four units bolted together, making eight cylinders acting on each shaft. The cylinders are 12 inches diameter by 8 inches stroke, and run between 550 and 600 revolutions per minute, and from the results obtained during a three hours' trial it was found that the average power exerted by each engine was 325.5 brake-horse-power, the engine running at an average speed of 382.5 revolutions per minute. The oil used was the Phœbus brand of paraffin S. G. 820, the consumption being 0.66 pint per brake-horse-power. There are a great many interesting points about this engine, both in regard to the cooling arrangements and in the use of a special form of paraffin vaporizer, which can be heated to exactly the requisite degree by a variable bypass on the exhaust. As in the Krupp engine, the camshaft is driven by gearing from a vertical shaft in the centre of the engine, and the reversing gear is of great simplicity. An example of a Diesel submarine is shown in the right and left-handed views in Figs. 23 and 24.

This is an eight-cylinder engine of the two-cycle, single-acting type, built by the Maschinenfabrik Augsburg-Nürnberg. The eight cylinders all operate upon the main shaft and give a total of 850 horse-power when the engine is running at 450 revolutions per minute. It will be noticed that in this case the camshaft is geared to a vertical shaft at the op-

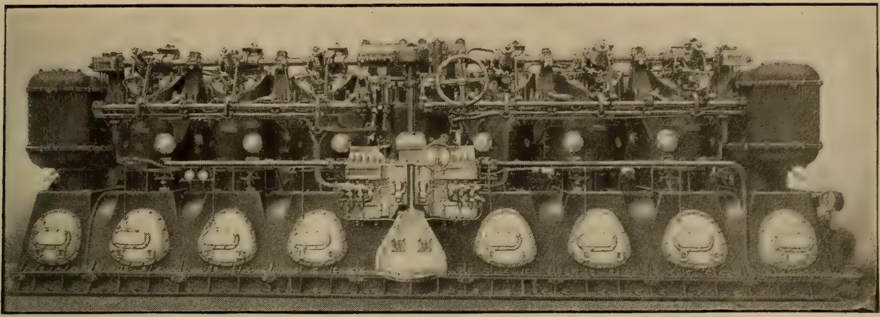


FIG. 21.—MARINE ENGINE OF 1,000 HORSE-POWER, BUILT BY MESSRS. KRUPP AT KIELGARTEN, GERMANY

posite end of the engine to the two-stage compressor. The reversing and control levers are at the compressor end. This type of engine can be constructed so that it weighs very little—about 35 pounds per brake-horse-power. Another reversible oil engine for marine purposes, built by the Italian firm of Fiat, is illustrated in Fig. 25. This is also of the two-stroke, single-acting type, and has six cylinders and gives 600 horse-power at 500 revolutions per minute. The two-stage compressor for the air blast can be seen at the end of the engine near the control box. No separate pumps are used for the scavenging, the working pistons being enlarged as illustrated in Fig. 11. The cylinders themselves are cooled with water in the usual way, but the pistons are cooled by the introduction of cooled oil, which in practice has proved quite effective. The construction of the valve gear cannot be followed from the photograph, but both the oil injection and the air scavenging valves on the separate cylinders are operated by cams worked by eccentrics on a horizontal layshaft, the arrangement being that if the layshaft is turned round 180 degrees relative to the crankshaft the eccentrics then operate the cams in the proper sequence but in the reverse direction, this change being effected by a combination of worm gearing on the vertical shaft. The

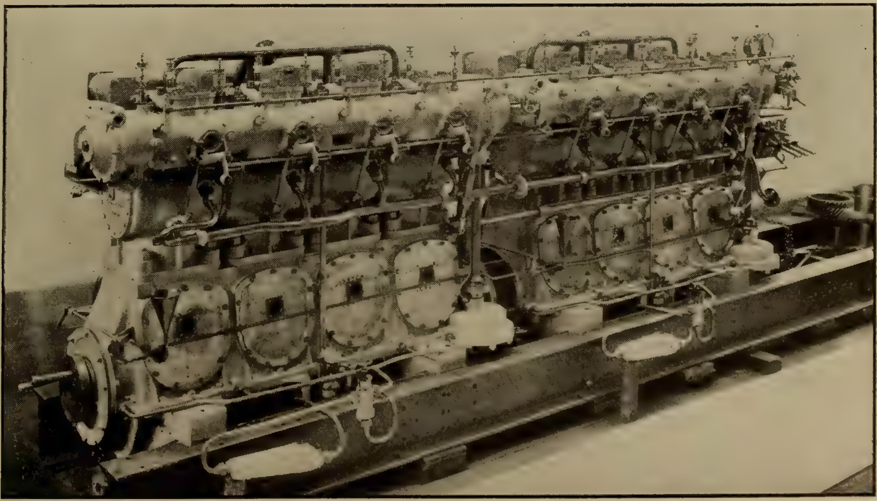


FIG. 22.—SUBMARINE FOR ROYAL ITALIAN NAVY, BUILT BY MESSRS JOHN I. THORNYCROFT & CO., LTD., CHISWICK, LONDON

control box is placed just in front of the air compressor, and the whole arrangement of reversing gear works very silently, and the change from full speed ahead to full speed astern can be effected in about five seconds.

The extent to which internal-combustion engines are now employed for submarines may be gathered from the fact that one firm alone—that of Gebruder Korting, of Hanover—has supplied eighty-two motors with a collective output of 22,000 horse-power, and have evolved a remarkable type of engine which is absolutely valveless. In some of these engines, built for the Russian Government, two sets of eight-cylinder engines are coupled behind one another, so that there are sixteen cylinders working a single screw. Unfortunately, illustrations of these are not available, but in Fig. 26 an illustration is given of a 115 H. P. Korting engine designed for a marine tender or launch. This runs normally at 475 revolutions per minute, but by regulating the oil pumps it can be slowed down to 150 or even 100 revolutions per minute. One of the peculiarities of this engine is the nature of the reversing gear; the main camshaft is shifted endways and the effective fulcrums of the levers working the valve rods are altered simultaneously. The arrangement of these engines has several very peculiar features, and is fully described in the *Schiffbau* of May 24, 1911.

The writer has referred to the term "semi-Diesel engine." Unfortunately, all makers do not attach the same meaning to this expression; but, generally speaking, it may be taken to apply to engines in which the necessary heat for the combustion of the oil is obtained partly by the act of compressing the air in the cylinder, as in the true Diesel, and partly by the use of a hot-bulb, which acts as a vaporizer. The well-known Bolinders engine, built at Stockholm, may be taken as a typical example of the hot-bulb type, and a section through one of the cylinders of this engine is shown in Fig. 27. It is a two-cycle, crankcase compression engine, and on the up-stroke of the piston air is sucked into the case through the aperture *B*, covered by

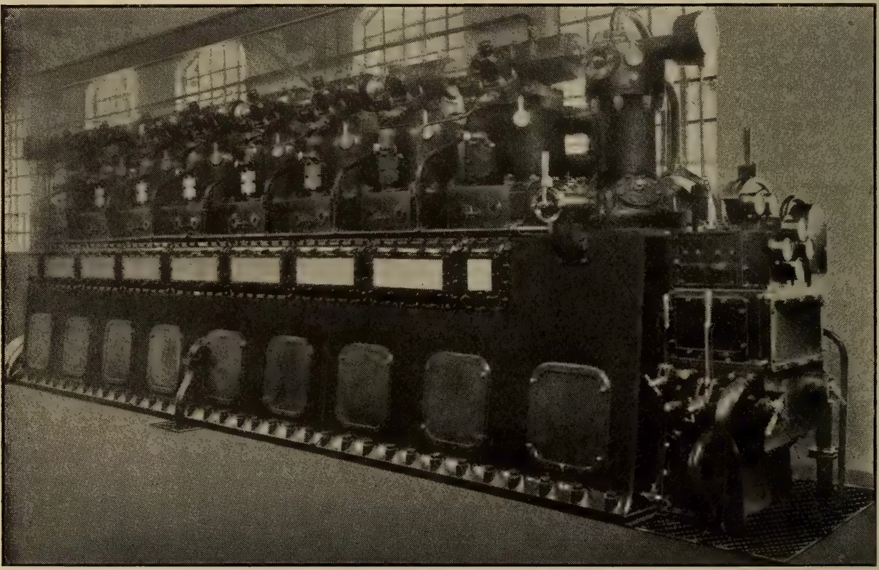


FIG. 23.—REVERSIBLE 850-HORSE-POWER OIL ENGINE FOR SUBMARINE BOAT, SHOWING COMPRESSOR END. BUILT BY MASCHINENFABRIK, AUGSBURG-NURNBERG, GERMANY

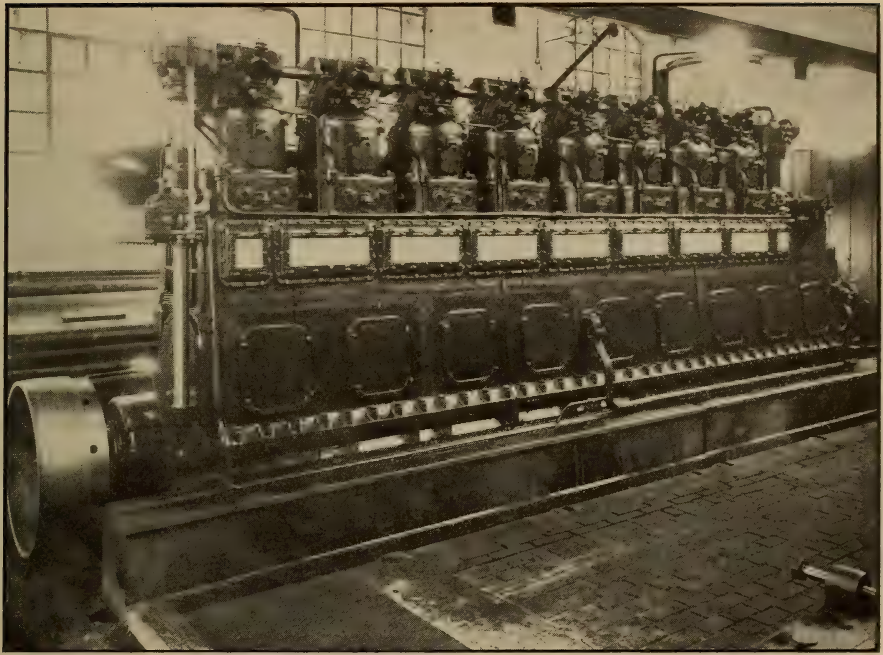


FIG. 24.—REVERSIBLE 850-HORSE-POWER OIL ENGINE FOR SUBMARINE BOAT, SPEED 450 R. P. M., SHOWING COUPLING END, BUILT BY MASCHINENFABRIK, AUGSBURG-NURNBERG, GERMANY

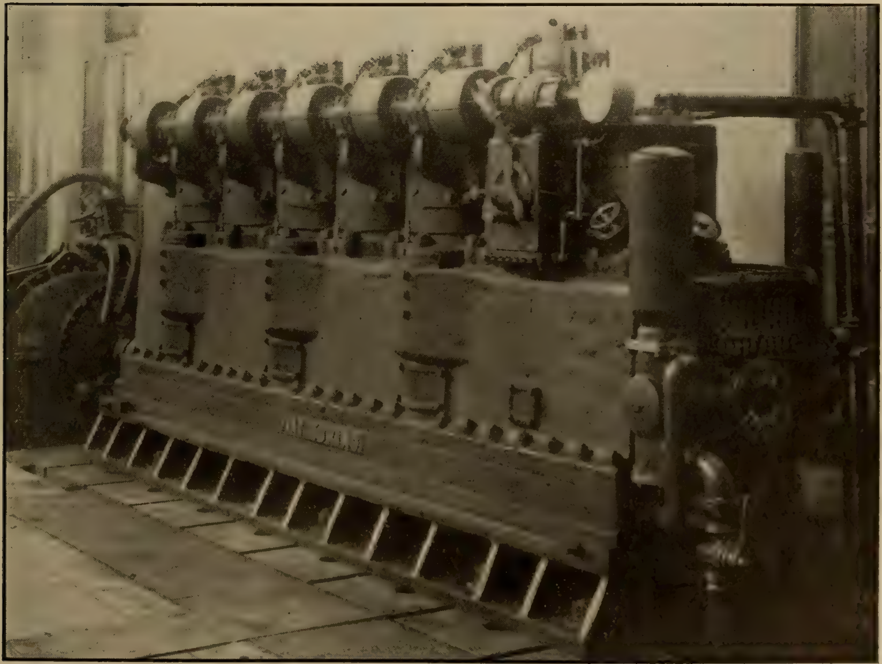


FIG. 25.—REVERSIBLE OIL ENGINE FOR SUBMARINE, BUILT BY FIAT SAN GIORGIO, SPEZIA, ITALY

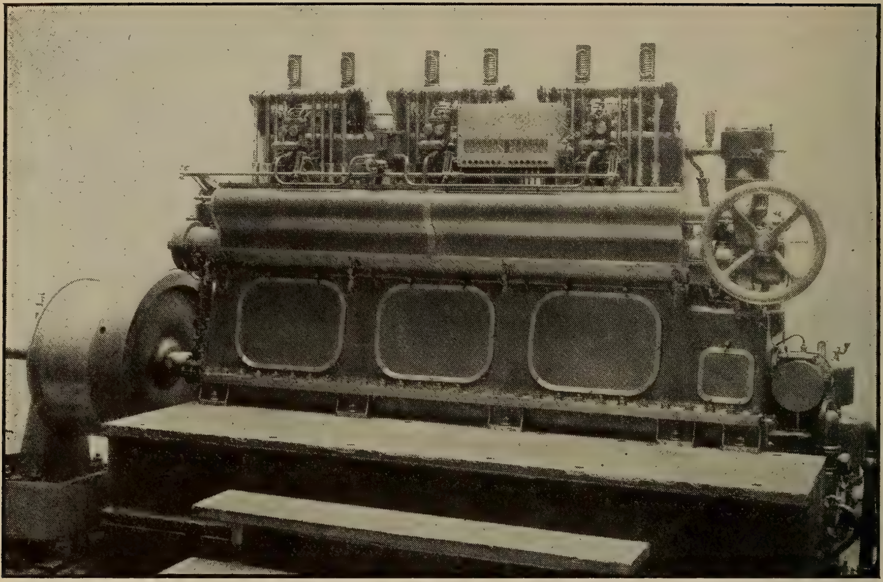


FIG. 26.—MARINE OIL ENGINE OF 115 HORSE-POWER, BUILT BY MESSRS. KORTING BROS., LONDON

a non-return valve. On the downstroke of the piston the air is driven up in the cylinder through the port *H,* and near the end of the compressor stroke a small oil pump injects the proper amount of oil through the nozzle *H* into the igniter ball *E,* where it is directly converted into vapour, which is automatically ignited, driving the piston downwards until the exhaust port *B* opens. Directly afterwards the inlet port *H* becomes uncovered and the compressed air in the crankcase rushes through the cylinder as a scavenging charge. Due to there being two ports between the igniter ball and the cylinder the ball is cleared out every stroke by the rush of fresh air through it. This cycle of operations gives one power stroke for every revolution in single-cylindered engines. Prior to starting up, the igniter ball or its equivalent hot-pot has usually to be heated up by a blow lamp for from ten to twenty minutes; after it has attained a dull-red heat the blow lamp may be removed.

Another two-cycle engine on very much the same principle is shown in Fig. 28, which represents a Kromhout engine of the R. O. type. These are built in Amsterdam by the firm of D. Goedkoop, Jr., and recently in England by Messrs. Plenty & Son, Newbury, Berks. The blow lamp used for the preliminary heating of the hot-bulb or vaporizing chamber can be seen at the back of the cylinder covers, and usually fifteen to twenty minutes are required for the preliminary heating of this engine. This is one of the engines in which a certain amount of water is drawn into the cylinder with the rush of incoming air, and it is claimed that the conversion of this water into steam reduces the amount of oil that has to be injected. The engine works with gas, oil, or solar oil having a flash point of about 130 degrees and costing at the present moment about 2¼*d.* per gallon.

The Beardmore engine, which is a development of the original Peck engine, is built somewhat on these lines, but in this case the oil is injected into the combustion chamber by compressed air at a pressure of 350 to 400 pounds to the square inch. The engine operates on the two-cycle principle, and is directly reversible. One of these engines of 120 horse-power, burning any of the crude oils, is shown in Fig. 29, which is reproduced from a photograph of the engine being fitted into the Marquis of Graham's yacht. The two-stage air compressor can be seen just behind the flywheel.

The Brons engine, which was described by the writer in an article on the Brussels Exhibition which recently appeared in this magazine, operates in a somewhat different way, as the fuel oil is injected, or rather drawn in, during the suction stroke; and while a portion of it is vaporized at once, the remainder is not burnt until near the beginning of the working stroke, after the primary explosion of the vapour has taken place. The patent rights of this engine for a good many countries have been acquired by the Gasmotorenfabrik Deutz, and an illustration of one of these engines for marine purposes is shown in Fig. 30.

The motor Sabathe is also a well-known example of the semi-Diesel engine, and there are several other allied designs before the public which may be classed generally as coming under the head of a combination of explosion engines and constant compression engines.

The ideal conditions for an internal-combustion engine to work under are those in which it runs at a constant speed, with a constant load, and always in the same direction. Un-

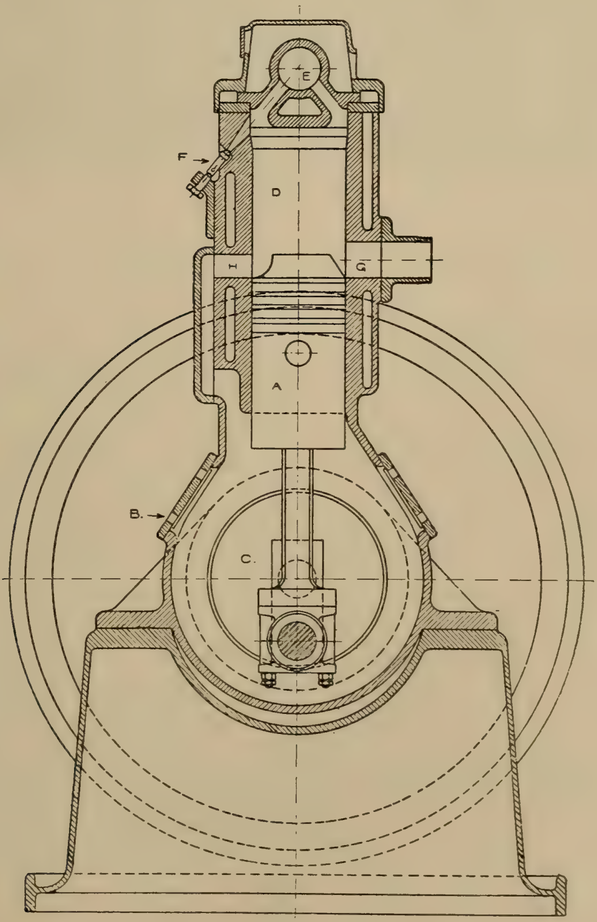


FIG. 27.—SECTION OF INTERNAL-COMBUSTION ENGINE, BUILT BY MESSRS. BOLLINDERS, LTD., STOCKHOLM

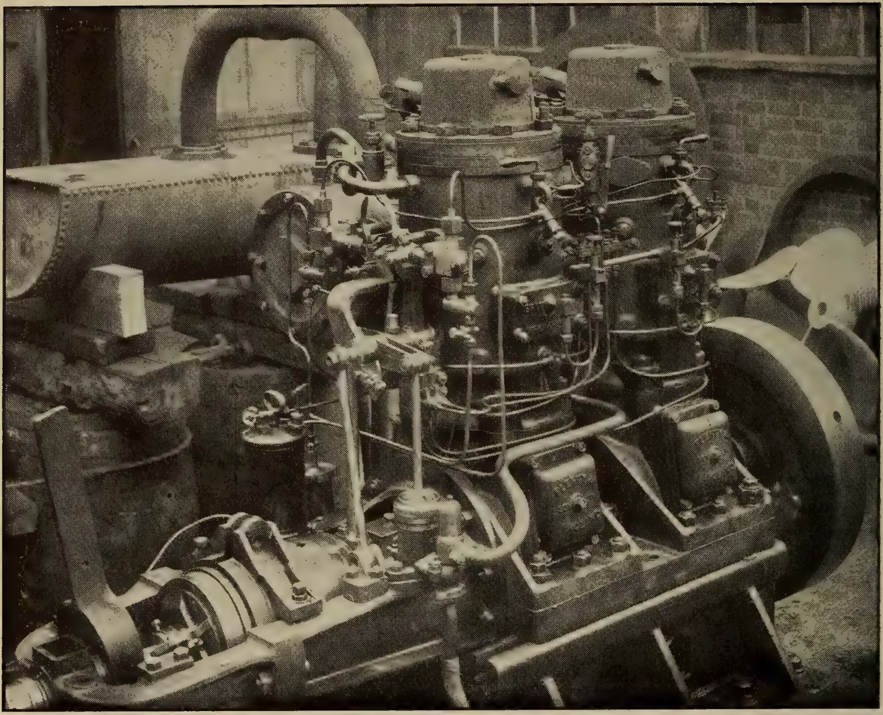


FIG. 28.—KROMHOUT ENGINE, BUILT BY MESSRS. PLEATY & SONS, NEWBURG, BERKS

fortunately, at sea the conditions are such that the motion of the boat must often be stopped and reversed as quickly as can be effected, and a considerable variation of speed must be provided, both for manœuvring and for the exigencies of the voyage.

There are several different methods of reversing the screw propeller relatively to the engine. The simplest, and one which is largely used for small boats, is to turn the propeller blades themselves in the hub, thus temporarily converting a propeller with a right-hand pitch into one with a left-hand pitch, and vice versa. This is generally effected by forming a rack on an internal rod in the propeller shaft, which rack gears with teeth on the shanks of the propeller blades.

In the second method of reversing the propeller shaft this is detached from the crankshaft of the engine, although it is in the same straight line with it and abuts against it; but the actual physical connection is made by means of a clutch and epicyclic train of wheels. An example of one of these devices used by Messrs. Brazil & Straker in connection with their Djinn engines is shown in Fig. 31. This is of the well-known differential bevel-wheel type, and is a very neat and compact arrangement. It will be seen that the gear wheels and cone clutches are all enclosed in the outer shell, so that oil throwing is impossible. When driving ahead, the whole system is clutched together and revolves as one, the gear wheels not rotating separately. For reversing, the sleeve is moved endways by the lever and the cone clutches at the other end of the arrangement engage. In the neutral position the reverse lever is central and the clutch surfaces are free. It may be noticed that provision is made to take all end thrusts by ball bearings. In some cases an arrangement of spur gearing, ar-

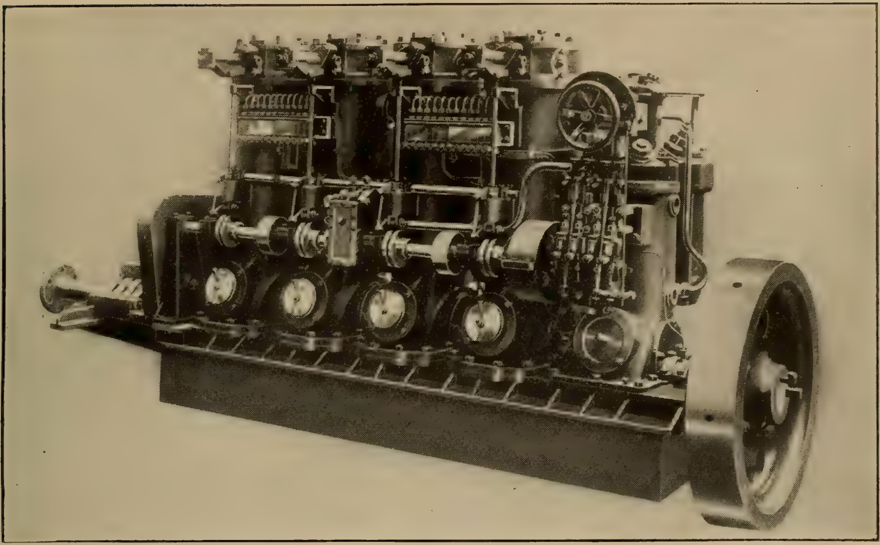


FIG. 29.—OIL ENGINE BUILT BY MESSRS. WILLIAM BEARDMORE & CO., GLASGOW

ranged on the sun-and-planet principle, is employed as an alternative to bevel gears; but in either case the results obtained are the same—namely, that the engine always goes in one direction, and may work the screw direct or it may run in the same direction and let the screw stand still, or it may run in the same direction and reverse the direction of the screw propeller.

In the third system, which is simply used on large engines, the propeller shaft and the engine shaft are permanently connected together, as in ordinary marine steam practice; and when reversing, the direction of rotation of the engine is changed as a

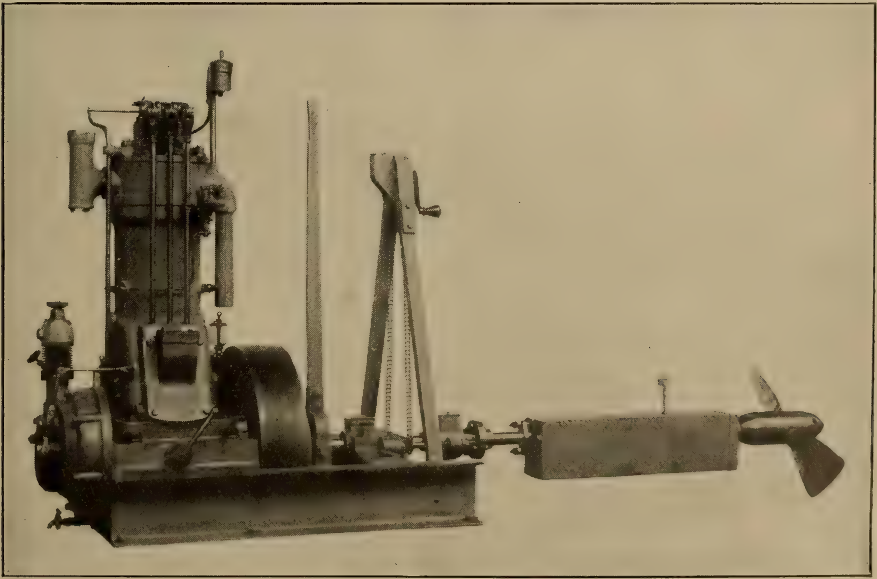


FIG. 30.—BRONS ENGINE BUILT BY GASMOTORENFABRIK, DEUTZ, GERMANY

whole; and, as a matter of fact, the actual reversing of the engine is nearly always done by throwing the fuel and air valves out of gear and manipulating the engine for the moment by an independent supply of compressed air. However, in small engines of the Bolinders type the motion of the piston is reversed by causing a premature explosion to take place intentionally.

It would be impossible to refer here in any detail to the different arrangements of valve gear used by various makers. Some makers use two camshafts, others alter the position of the camshaft relative to the crankshaft, and some again mount all their working cams on one long shaft and shift this endways in the same way as the barrel of a musical box is moved to change the tune.

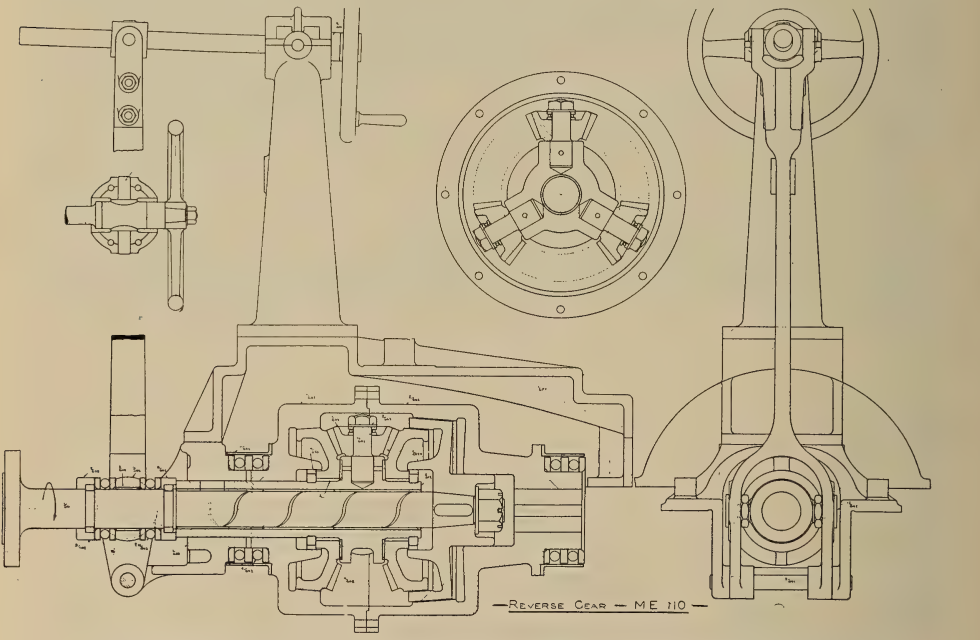


FIG. 31.—REVERSING GEAR USED IN DJINN ENGINE BY MESSRS. BRAZIL, STRAKER & CO., BRISTOL

The reversing problem is considerably simplified in the two-cycle engine owing to the absence of exhaust valves.

None of these arrangements of valve gear provides for any variations of speed other than that obtained by regulating the supply of fuel to the engine, and there are certain inconveniences attendant on this; and at very low speeds, or where the propeller is suddenly deeply immersed, the engine may fail to fire the charge automatically. This particular difficulty may be got over by allowing the high-pressure air supply to come automatically into operation for the time being, but this does not solve the problem from a general point of view. For instance, in the navy a war vessel may be called upon to develop its maximum horse-power at comparatively remote intervals, and when cruising at low speeds only a fraction of this power is required. In a specification taken out last year by J. E. Thornycroft he met these conditions in rather a bold manner by proposing to install turbines or steam engines capable of giving the maximum power when the ship is driven at full speed and to combine with these internal-combustion engines, which would be used to propel the ship under cruising conditions, these internal-combustion engines being disconnected when necessary by some form of clutch or gearing. At the present moment the firm of Thornycroft is actually building for the British Navy a vessel which will contain turbines equal to 20,000 horse-power combined with 2,000 horse-power Diesel engines for cruising purposes. There seems to be a good deal to be said for an arrangement of this sort for the particular purpose.

Recently a number of propositions have been put forward for transmitting power from electric generators on the engine shaft to motors on the propeller shaft.

In some of these systems the drive is wholly electric, and the engine may be of any shape or form as long as it turns the generators. In the alternative system the drive is mechanical down to a certain point and becomes electrical only after this—say at anything under half-speed.

Messrs. Mirrlees, Bickerton & Day, the Diesel engine makers, have worked out an arrangement of this kind, which is shown in Fig. 32. This was proposed for an oil-carrying vessel of 1,800 tons, and the propelling power consists of two Diesel engines of 300 horse-power running normally at 250 revolutions per minute. A dynamo is fixed on the engine crankshaft and a motor on the propeller shaft; when running at anything above half speed both shafts are clutched together, but below full speed or when running astern the clutch is disconnected and the generator on the engine drives the motor on the other shaft. The electrical gear is also used when reversing. The electrical portion of the apparatus can be kept of comparatively small and compact size, as when going at half speed only about one-eighth of the power has to be applied.

The Del Proposto system, which met with considerable vogue among the Russian builders, provided for a semi-electrical drive of this kind and also a wholly electrical one. This system was referred to by Mr. Vennell Coster in his previous article in the Gas Power Number of this magazine.

Mr. H. A. Mavor, of Glasgow, is another inventor who has taken out a number of patents and read several papers before the learned societies on electrical transmission on board ship. In a paper read before the Institution of Civil Engineers on December 7, 1909, he describes a rather remarkable arrangement which he terms a

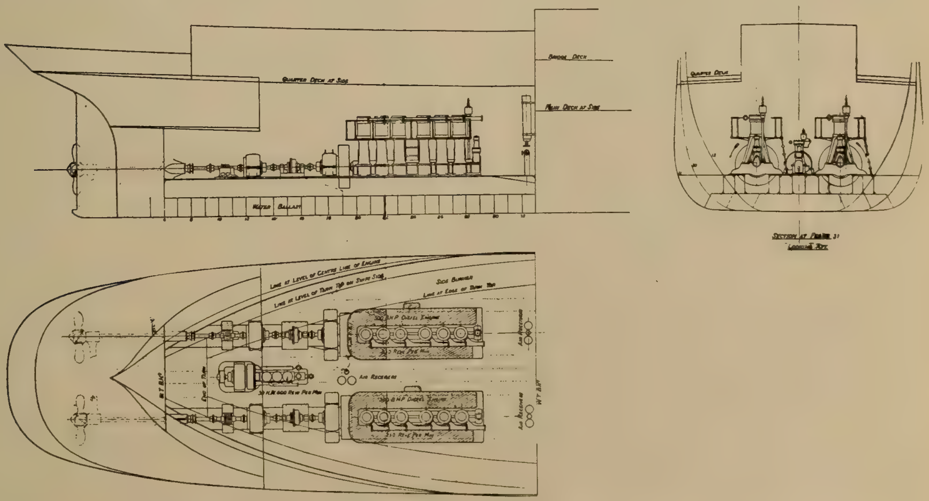
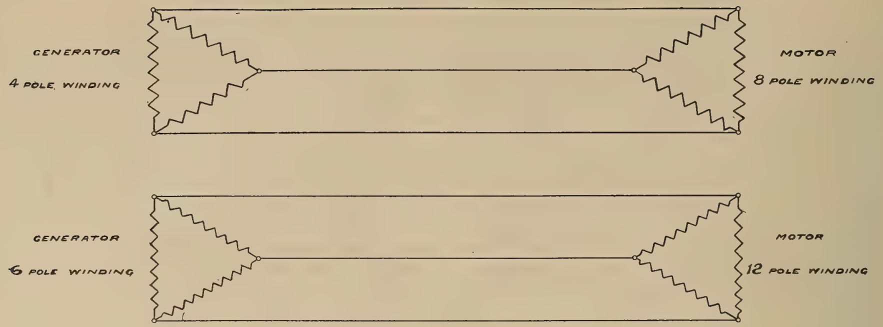
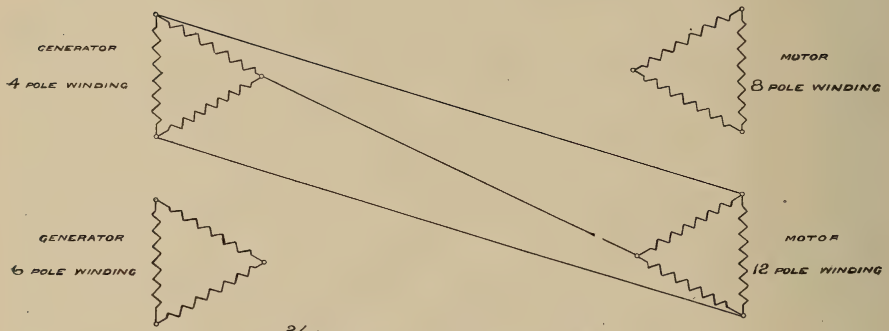


FIG. 32.—ELECTRIC DRIVE WITH DIESEL ENGINE, DESIGNED BY MESSRS. MIRRLEES, BICKERTON & DAY, LTD., STOCKPORT



FULL SPEED CONNECTIONS



⅔ SPEED CONNECTIONS

FIG. 33.—DIAGRAM OF ELECTRICAL CONNECTIONS USED BY H. A. MAVOR, OF GLASGOW

"spinner motor," but the writer is unaware as to whether this has ever been put into practice on a large scale. However, Mr. Mavor's ideas as to electrical transmission have so far materialized that at the beginning of the present year the *Electrical Ark,* a small craft 50 feet long, was equipped with an electric drive. In this particular arrangement a three-phase generator was driven direct by the engine. The generator had two windings on it, and the motor on the propeller shaft had also two windings with different numbers of poles, one combination giving the full speed of 7.25 knots and the other combination giving about two-thirds of the full speed, 5 knots. The reversing of the propeller was also effected by electrical means, taking about 13 seconds. A diagram of the electrical connections for full speed and two-thirds speed is given in Fig. 33.

Another plan, the so-called Paragon system of electric transmission, has recently been brought prominently before the public by Mr. W. P. Durtnall, and the writer is indebted to him for having prepared a diagram of a scheme, an explanatory diagram of which is given in Fig. 34. In this arrangement there are three sets of Paragon Diesel engines running approximately at 400 revolutions per minute, which speed is arranged to suit their best efficiency. These engines generate current which is transmitted to the propeller shaft through a direct coupled induction motor running at 83 revolutions per minute, which in this case would be the best speed for the screw. When the Diesel engines are running normally the same thrust is exerted on the screw propeller as if a steam engine of equal power were coupled direct. The combination provides for

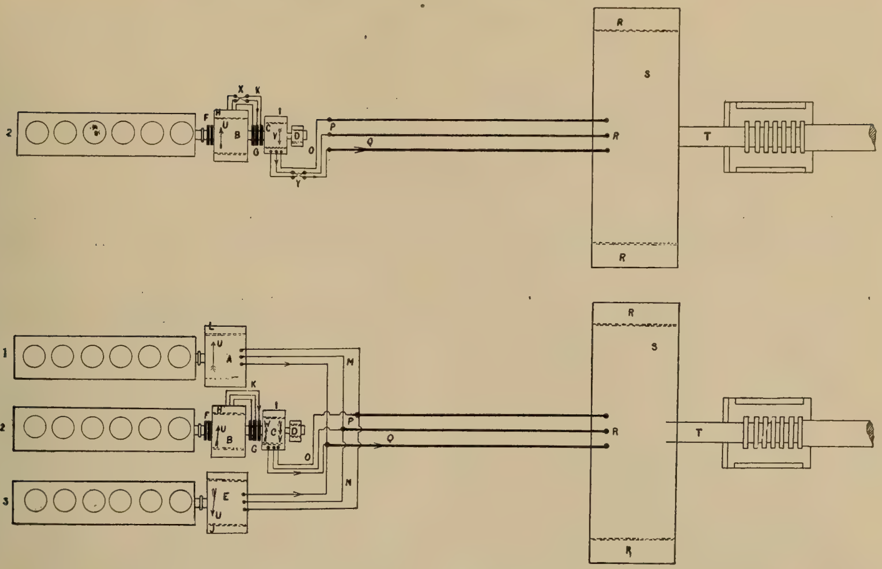


FIG. 34.—DIAGRAM OF W. P. DURTNALL'S SYSTEM OF ELECTRIC PROPULSION

three speeds ahead—say 4, 8 and 12 knots—and the changes and combinations are effected by purely electrical means. The end of the shaft is directly coupled to a low-resistance and low-voltage squirrel-cage rotor *S* revolving in a stator *R,* which is barred round with heavy bars to form fifty-six magnetic poles. Fig. A shows the connections for going at the lowest speed ahead and having only one engine at work, this engine having coupled to it a synchronous generator having a rotating 8-pole magnet revolving in the stator armature in which the three-phase alternating current is primarily generated. A prolongation of the same shaft also drives the revolving primary member *C* of a four-pole transforming generator working in the stator secondary member *I,* which either adds to or subtracts from the frequency generated in the armature of the synchronous generator *H.* A small continuous-current generator, giving the current for exciting purposes, is further fixed to this shaft. This is indicated by *D.* The reversal of the motion of the screw propeller is effected by changing two of the phases at *Y,* and this is done under no-voltage conditions by momentary interruption to the exciting circuit. The other two engines, marked 1 and 3 in Diagram B, come into use when running full speed ahead, and drive non-synchronous generators of the squirrel-cage type at the rather higher speed of 420 revolutions per minute. The electric connections between the generators and the large motors driving the screw propeller are shown by the dark lines *Q.* These are the only physical connections between the generator and the motor.

In connection with such a system Mr. Durtnall proposes to use a modification of the Diesel engine built on the Bowles-Durtnall system, and, if the inventor's expectations of obtaining a horse-power-hour for 0.36 pound of crude oil are realized, it will be an additional point in favour of the oil engine at sea.

The relative merits of the various systems of electric propulsion have been very well dealt with in Mr. H. M. Hobart's recent book, "The Electric Propulsion of Ships."

The hydraulic transformer recently invented by Prof. Fottinger is another and totally different method of varying the speed of the propeller and reversing without interfering with the running of the engine. The writer has not attempted to describe the details of this very ingenious arrangement. Briefly, it may be stated that the propeller shaft is separated from the crankshaft of the engine, and the apparatus may be considered to consist of two portions, one a turbine pump on the crankshaft which delivers water under pressure to a water turbine keyed on the propeller shaft, which latter water turbine again delivers the water which has passed through it back to the impeller on the crankshaft, the same volume of water going round in a circle. A little consideration will show that a wide variation may exist between the speed of the pump on the engine and the speed of the turbine on the propeller shaft. A very efficient turbine pump can be made to run at a high speed, and an equally efficient water turbine can be made to run at a low speed. Perhaps the idea can be better grasped if the turbine on the propeller shaft was considered to be fed from an independent reservoir. A wide range of reduction can be obtained by this arrangement, and in the *Holzapfel I.* the normal reduction is from 450 revolutions per minute on the engine to 120 revolutions per minute on the propeller shaft. By reversing the guide blades which direct the flow of water from one member to the other the direction of rotation of the propeller shaft can be reversed.

Although this article has been entitled "The Possibilities of the Internal-Combustion Engine for Marine Purposes," it has of necessity been only a record of what has actually taken place and the way events seem to be moving. The next two years will prove, if not the limitations of the gas and oil engine at sea, at least the lines on which these limits will be reached. Apparently the present tendency is to build engines of the type exemplified by the Krupp engine shown in Fig. 21, and the writer has seen the working drawing of a 8,500 horse-power Diesel engine in which six cylinders only will be employed, and it is well known that even larger units are now being designed.

The 2,000 horse-power single-cylinder Sulzer engine shows what can already be done.

The economy of the internal-combustion engine for marine purposes, both in the way of fuel consumption, saving of space and reduction of deadweight, is unquestioned, and their general employment depends largely upon whether they can be regarded as absolutely reliable, or at all events as reliable as an ordinary steam engine; and the aim of the engine builders should be to eliminate every possible working part that can be dispensed with.

The adoption of the Diesel principle gets rid of nearly all ignition and pre-ignition troubles, and the use of the two-cycle arrangement dispenses with exhaust valves; and, as a matter of fact, some types of engines can be built to work without almost any valves. Given a really reliable system of variable transmission, be it hydraulic or be it electric, used in conjunction with a valveless engine always running at the same speed in the same direction, and there will be obtained practically an ideal condition of affairs.

In conclusion, the writer wishes to express his best thanks to the numerous firms who have rendered assistance in furnishing information and photographs, and at the same time to acknowledge the courtesy of the editor of the *Motor Boat* in allowing him to reproduce several unique illustrations.

# THE ARRANGEMENT AND CONSTRUCTION OF OIL VESSELS

By J. Montgomerie, B. Sc., Eng. (Lond.), M. I. N. A., Surveyor to Lloyd's Register

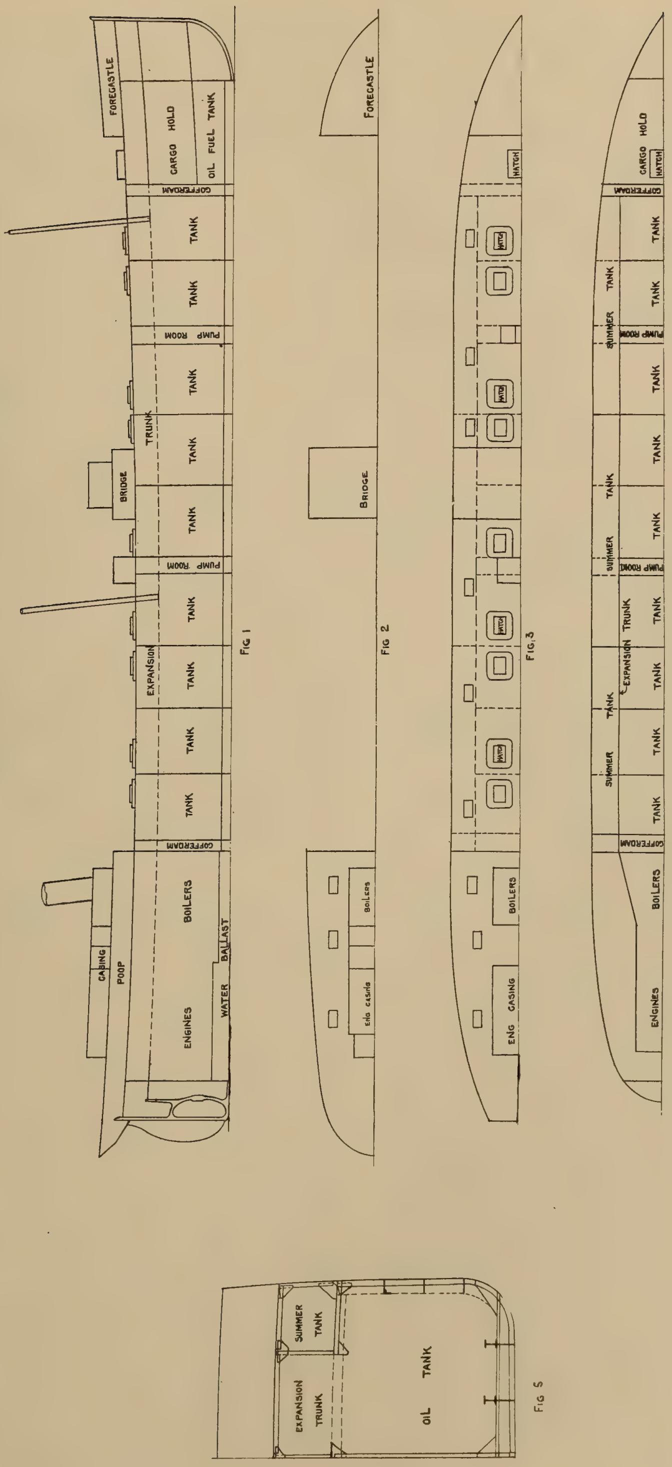
THE development of the maritime and other industries connected with, and dependent upon, the transport of petroleum in bulk presents very many interesting features. Since the discovery of petroleum in America fifty-five years ago there has been a continuous, although not a uniform expansion, in these industries, and this expansion is nowhere more plainly seen than in that part of the industrial field which is concerned with the marine transport of petroleum. In 1886, for example, although the production of petroleum in America has increased so rapidly as to place this commodity fourth in the list of American exports, the arrangements then in vogue for its transport to European and other countries were what would now be considered of rather a primitive nature. Nearly all petroleum shipped from America at that date was carried in iron barrels or cases made of tinplate and cased with wood. The vessels engaged in this trade—not at that time a very safe or lucrative one—were wooden sailing ships, for the most part foreign owned. Gradually, however, economic pressure in the over-sea carrying trade caused British shipowners to enter this field, and to their enterprise and energy the present efficient state of this industry is largely due. The nature of the achievements of the intervening years may be gauged from the fact that while in the year 1893 there were approximately 80 vessels of an average gross tonnage of 2,500 tons engaged in this trade, at the end of June of this year there were 282 vessels engaged exclusively in the carriage of petroleum of an average gross tonnage of 3,050 tons. The proportion existing between steam and sailing tonnage has been inverted, and there are to-day 234 steamers of a total gross tonnage of 782,550 tons engaged in this trade, as against 48 sailing vessels of a total gross tonnage of 79,540 tons. These years have also witnessed, except in particular cases, the displacement of cases and barrels as a means of transport by the modern tanker with special and complete pumping plant for loading and discharging. At the present time, due to the obvious and inevitable increase in the world's demand for petroleum and other similar oils, we are witnessing a renewal of the building activity of this particular class of vessel which occurred some years ago, and the demands of owners in respect of the modern tanker constitute, for the naval architect, problems of quite exceptional interest and complexity. The cargo carried is a liquid often of an extremely volatile nature, of different degrees of density, carried in separate tanks which must be completely isolated from one another. It is susceptible of changes of volume consequent upon changes of temperature, and is at all times ready to give off gases which, when combined with air, form an explosive mixture of enormous potential energy. It is thought that an attempt to set forth some of the conditions of the problems confronting the designer, and the experimental and other solutions of these problems as represented by the construction and design of the modern oil steamer will, at the present time, have at least a topical interest.

GENERAL ARRANGEMENT

The general arrangement of a typical modern vessel of this kind, showing profile, deck plans and 'midship section, is given in Figs. 1 to 5. The machinery is fitted aft, the whole of the 'midship part of the vessel being utilized for the oil cargo. A short forecastle is fitted, a poop covers and protects the engine and boiler space, and a short bridge amidships houses the officers and engineers. The presence of this short 'midship erection at once differentiates this type from the ordinary cargo carrier, which usually has a strong structural erection amidships, covering sometimes a considerable part of the vessel's length. The tanks are of an average length of 28 feet, divided longitudinally by a continuous middle line bulkhead. Provision for expansion and contraction of the oil is made by means of a continuous trunk, of a width approximately equal to half the width of the vessel (see Fig. 5), while the oil space proper is isolated from the machinery space at the aft end and from the cargo space at the forward end by means of safety spaces, or "cofferdams," two frame spaces in length. The provision for expansion and contraction of the oil was formerly made by means of isolated rectangular trunks in the 'tween decks, the volume of which was a stated percentage of the volume of the oil tank it served. It was not long, however, before a more excellent way was found, and the present continuous expansion trunk contributes not only a very desirable addition to the structural strength of the vessel, but also, from the owner's point of view, a very desirable addition to the vessel's carrying capacity. It is desirable, however, to impose some limit to the width of the expansion trunk, for two reasons. First, it is very desirable that the *width* of the free oil surface should be subject to some restriction, so as to obviate any undue diminution of the metacentric height. Secondly, it is desirable to have this width restricted, so as to minimize, as far as practicable, the stresses incident upon the sides and ends of the trunk when the vessel is rolling and pitching in a seaway. From all points of view, except the purely cargo-carrying one, it is advisable not to allow the width of the trunk to exceed half the width of the vessel.

The question of the position of the machinery in an oil vessel (see Fig. 1) is one on which some difference of opinion exists. Whether shall the machinery be fitted aft or amidships? This question may be answered by saying that, in practice, most oil steamers have their machinery placed aft, and in the vessels now being built to class in Lloyd's Register the machinery is fitted aft in every single instance, so that, apart from considerations of trim, etc., this practice appears to be increasing. There are two principal reasons which operate to decide owners in this direction. The first is a saving in original cost. When the machinery is placed amidships it is necessary to fit a circular oil-tight tunnel for the shafting, extending aft from the engine-room bulkhead—a somewhat expensive and complicated piece of work, which is entirely dispensed with if engines are aft. There are also involved obvious economies represented by decreased length of shafting and the number of bearings which require lubrication.

The second reason is also one that always appeals to the owner, and consists in an ability to carry more dead weight. For example, a vessel of 6,000 tons dead weight carrying capacity with engines fitted aft will carry approximately 150 tons more than the same ship with engines placed amidships. On the structural side of the question there does not appear to be any considerable balance of advantage in favour of either method. It might be pointed out, however, that when machinery is fitted aft it is possible for the strong



FIGS. 1-5.—GENERAL ARRANGEMENT OF OIL-TANK STEAMSHIP

structure of the oil tanks to extend uninterruptedly for three-fourths of the vessel's length amidships. When fitted amidships, the tank structure is broken, the middle line bulkhead does not extend through the engine and boiler space, and it is rather a difficult matter effectively to provide against so decided a discontinuity of structural strength, occurring, as it does, within a few feet forward and aft of amidships, respectively.

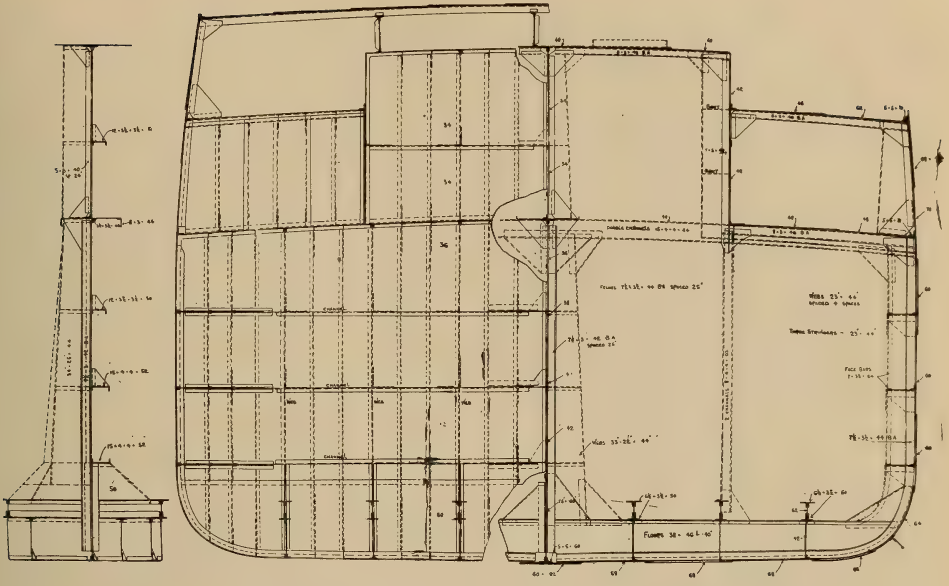
An indispensable part of the general arrangement of an oil tanker is the provision of safety spaces or cofferdams which isolate the oil tanks from the other parts of the vessel. These cofferdams extend right across the vessel up to the level of the top of the expansion trunk, and it is essential that they possess two characteristics. The first is that they should be known as cofferdams by all on board, so that every necessary precaution may be taken on entering them. The practice of utilizing the cargo hold forward as a cofferdam is an undesirable and, let it be said, an uncommon one; and it is not too much to say that no compartment which can at any time be used for any other purpose whatever should be utilized as a cofferdam, as in that case the real purpose for which the space is fitted is masked and due care may not be taken in entering it. The second characteristic is the rather obvious one that they may be easily entered and examined. In order economically to use material, the two bulkheads are stayed together inside the cofferdam, and as these stays are arranged in tiers, spaced a short distance apart, it is essential that the cofferdam should be of a length sufficient to make access to it easy. In all except very shallow vessels the length of the cofferdam should not be less than two spaces of frames.

As might be expected, nearly all modern oil steamers burn liquid fuel, and this is usually carried in fuel bunkers placed in the vicinity of the boilers, and also in a long tank fitted underneath the forward cargo hold (see Fig. 1). Care is necessary in the design of these tanks, for the conditions differ from those obtaining in the ordinary oil tanks in the respect that the fuel oil tanks will become only partially filled as the voyage proceeds and the oil is burned out. This leads to greater impulsive forces on the boundaries of the tank, which must be provided against. Means are also taken to prevent leakage out of any of these fuel-oil compartments from coming into contact with cargo or finding its way into the engine-room bilges; the pumping arrangements also of these compartments and of their wells are kept quite distinct from those of other parts of the vessel.

Before leaving this part of the subject it may be pointed out that the disposition of the oil space relative to length of vessel is nearly uniform in all cases and follows from the necessity for securing the necessary trim by the stern when loaded. The oil space proper terminates about 65 feet from the collision bulkhead, leaving a small hold, which, however, is seldom used for carrying cargo.

### THE HULL STRUCTURE

It is in the design and combination of the materials forming the structure of the vessel that the designer meets with his most difficult problems, and this is so because of the many conflicting conditions which have to be considered. Look, for a moment, in this connection at the nature of the cargo he is dealing with. Unlike the majority of cargoes carried in merchant steamers, it rests directly upon the shell plating of the ship instead of upon the internal floors and frames, and thus severe stresses are induced on the rivets connecting the plating to these girders. This effect is greatly increased by the inertia of the fluid cargo when the vessel is pitching or rolling in a seaway. It is to be noticed also that both plating and rivet-



FIGS. 6 AND 7.—STRUCTURE OF OIL-TANK STEAMSHIP

ing are subject to fluctuating stresses which cannot be insignificant either in rate or range. We are becoming increasingly aware of the fatigue induced in materials under such conditions. It is now known that, under conditions of repetitive stress, resistance to rupture depends not so much on the maximum stress of one kind or the other as upon the algebraic difference of the stresses; that fracture may take place for a stress much less than the elastic limit of the material if repetition takes place a certain number of times; and there appears reason for believing that many cases of structural damage in oil vessels may be explained by some such considerations as these. Again, it is to be remembered that each tank must be oiltight, and must be demonstrated to be so by a water test of considerable severity, and that in many cases the arrangement of riveting sometimes necessary to secure oiltight work is not the best structural arrangement. When one takes into full consideration facts like these, we believe it to be matter for congratulation that the difficulties inherent in the question have been so well overcome.

The structural design of oil ships in its earlier stages developed along experimental lines, and has been fixed rather by successive trial and error than by any conscious reference to recognized principles of construction. The earliest oil ships were ordinary merchant vessels converted to their new purpose, and this fact very likely materially influenced the construction of the more complex structures which succeeded them. The structure of the oil tank steamer of to-day is sufficiently indicated by Fig. 6, which represents a section amidships showing the scantlings of shell plating frames, etc., and the construction and scantlings also of the transverse and middle line bulkheads.

The system of framing almost universally adopted is the web frame system, and many reasons could be adduced supporting the claim of this particular type of framing to be considered eminently suitable for oil vessels. In the first place, it will readily be seen that rigidity is much more necessary in a vessel of this kind than in the ordinary merchant vessel, and the most rigid of all methods of framing vessels is that known as the web frame system. The objection often urged against it in ordinary cargo ships—that it obstructs stowage—does not hold good when a liquid cargo is carried. As is well known, the framing consists of vertical webs, horizontal plate girders and intermediate vertical bulb angle frames. The web frames and stringers have strong face angles fitted on their inner edges, and the former are spaced four spaces of frames apart, there being two of them usually in each tank. The load on the side in any ordinary case is borne by the web frames alone; but in an oil ship this load is borne by the web frames in association with the side stringers, because the close spacing of the bulkheads makes the stringers almost as efficient as the webs in undertaking this work. This constitutes a further reason in favour of this type of framing, for whereas in an ordinary merchant steamer with bulkheads seventy or eighty feet apart the stringers act merely as intercostal supports to the shell and as supports of the intermediate frames between the webs, in an oil vessel with bulkheads twenty-eight to thirty feet apart not only do they perform these two important functions, but they also, on their own account, distribute part of the external load to the end abutments—the bulkheads—which may be regarded as rigid sections. In calculating the strength of the vessel's framing, therefore, allowance must be made for this *structural* function of the side stringers; and it will be found, even on the most cautious assumptions, that a considerable accession of strength results. The longitudinal and transverse bulkheads are stiffened on the same principle as the side of the ship—viz., by a series of vertical webs, horizontal girders and vertical intermediate stiffeners; and it can be easily understood by an inspection of the sketches how naturally the arrangements adopted on the transverse and longitudinal bulkheads work in with each other and with that on the side of the vessel. See Fig. 8, which shows a plan of the bulkhead stiffening. The side stringers on the shell plating and the horizontal channels on the transverse and longitudinal bulkheads constitute a complete belt extending around the vessel, and securing, therefore, a great amount of rigidity at the end connections. The vertical webs are arranged in line with the side keelsons, and the same desirable result is attained. The bottom is supported by ordinary straight floors and side keelsons, so that we may say that the bounding surfaces of the oil tanks are each supported on the same principle by a system of stiffening which makes continuity at the intersection of these surfaces easy and natural. The remarks made regarding the strength of the side apply with modified force to the bulkheads and bottom. The load in each case is borne by two sets of girders, and is distributed to the end supports in proportion to the *stiffness* of each girder; and, just as the side of an oil vessel can easily be shown to be considerably stronger than that of an ordinary cargo steamer, in the same way and for the same reason the bottom also is very much stronger than the bottom of an ordinary cargo vessel.

Although, as has been said, the structure has been developed along experimental lines, it is difficult, so long as we confine ourselves to transverse framing, to conceive an alternative to, or to define any fundamental departure from, arrangements which are so obviously suggested by the conditions to be fulfilled. This type of structure is the one approved by Lloyd's Register of Shipping after very careful consideration, and is embodied in their rules. It has been adopted in all kinds of vessels, from the largest to the smallest, and, considering the work to be done, with surprisingly good results.

While it is true that the system of

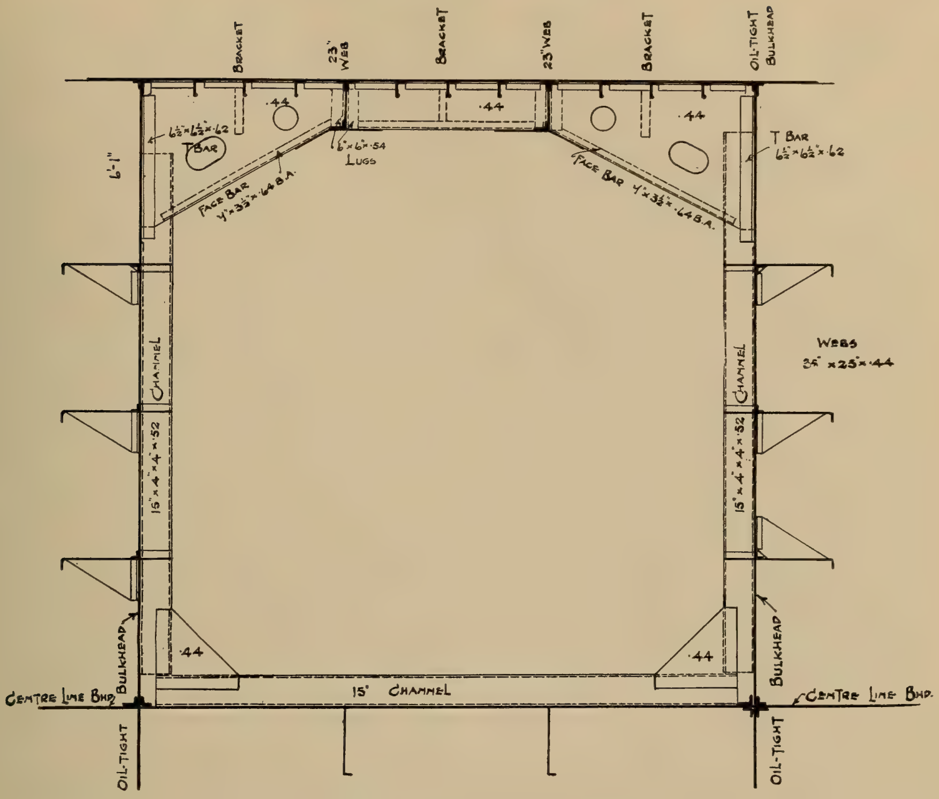


FIG. 8.—PLAN SHOWING BULKHEAD STIFFENING

construction briefly discussed in the foregoing has not sensibly changed during recent years, there has been constant change proceeding in that important part of the design which may be described as structural detail. Experience has shown the absolute importance of attending to matters of this kind in oil vessels. It is of vital importance, for example, that the riveting of oil vessels should be attended to with the greatest care, and adequately to deal with this part of the subject alone one would require more space than is available in an article of this kind. The importance of sound riveting may be gauged when it is realized that a study of the structural damage found in oil ships shows that a considerable proportion of it consists of loose, started and fractured rivets, especially where the keelsons and stringers cross the transverse bulkheads, rather than of fractured material. When the rules of Lloyd's Register for vessels intended to carry oil in bulk were being prepared, special consideration and discussion were given to that portion of them dealing with riveting and riveting details. All the ordinary precautions familiar to readers are taken and certain additional requirements are made. The use of the drift punch is absolutely prohibited, all unfair holes being rimered and rivets of a larger diameter used in the rimered holes. It is very necessary also in this class of work that the steel surfaces should be in absolute contact, and care must be exercised in removing all burrs, due to punching, or particles of drilled or rimered material from between the surfaces before the work is screwed up. The rivets are, for the same thickness of material, of the same diameter as those used in ordinary ship work, but are spaced more closely. The more important structural details requiring special attention are those connected with the attachment of the side stringers and keelsons to the bulkheads, the arrangements at the ends of expansion trunks and middle line bulkheads. In regard to the keelson and stringer attachments, a good deal of trouble has been experienced at the bulkheads, due, no doubt, to the structural functions they are called upon to perform in oil ships, which have already been alluded to. Double-riveted connections are, therefore, required at these places, and the sketches in Figs. 6 and 7 show the three-ply connection usually adopted. Builders, however, concerned to secure oil tightness have a natural and invincible objection to three-ply work, and some oil ships have been constructed where single double-riveted angles have been substituted for the double angles shown in Fig. 7. This, while it secures the absence of three-ply work, also involves a less efficient riveted connection, since the pull along the axis of the rivet is resisted by the rigidity of the bulkhead plating alone. The objection to three-ply work consists largely in the difficulty of efficient riveting, and this, to a great extent, disappears when arrangements are adopted permitting of hydraulic riveting. Accordingly, we find many modifications of construction proposed, in order to get over this riveting difficulty, some of which are ingenious and, at the same time, structurally efficient.

The sound practice which aims at the minimizing of discontinuity of material is exemplified in other details of construction. The expansion trunk, for example, should not be

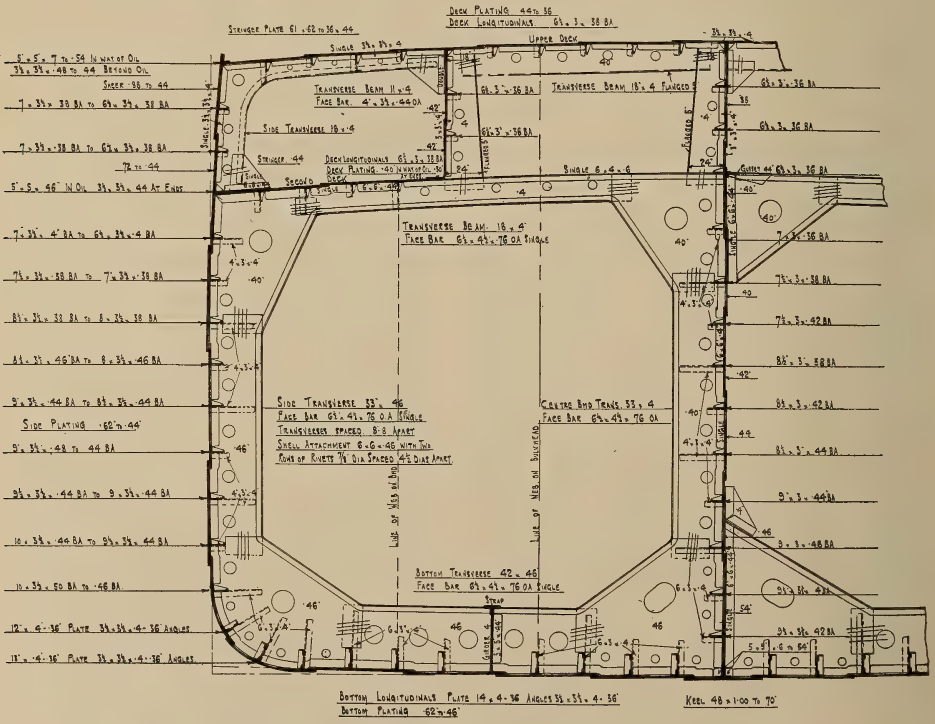
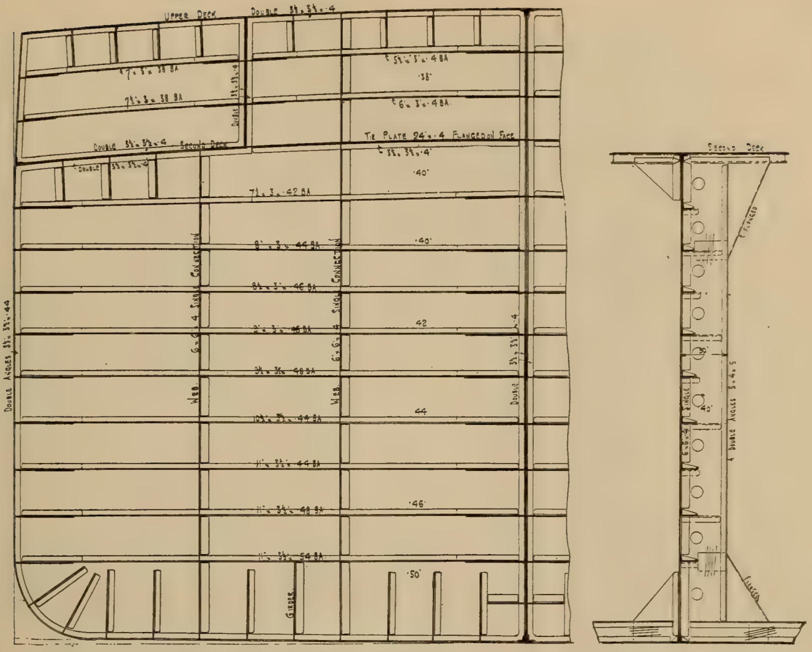

Deck Plating 44 to 36
Deck Longitudinals 6½ × 3 × 38 BA
Stringer Plate 61 × ·62 to 36 × 44
Upper Deck
- 3½ × 3½ × ·4
Single 3½ × 3½ × 4
5' × 5' × 7 to ·54 In way of Oil
3½ × 3½ × ·48 to 44 Beyond Oil
Sheer ·88 to 44
7 × 3½ × 38 BA to 6½ × 3½ × 38 BA
7 × 3½ × ·38 BA to 6½ × 3½ × 38 BA
72 to ·44
5' × 5 × 46" In Oil 3½ × 3½ × 44 At Ends
Single 3½ × 3½ × 4
Transverse Beam 11 × ·4
Face Bar. 4' × 3½ × ·44 OA
Side Transverse 18 × ·4
Stringer. ·44
Deck Longitudinals 6½ × 3 × 38 BA
Deck Plating. ·40 In way of Oil ·30 At Ends
Second Deck
Single
6 × 6 × ·44
Double
·42
4
3 × 3 × ·4
24
6½ × 3 × ·36 BA
6½ × 3' × ·36 BA
Flanged 5
Transverse Beam 18 × 4 Flanged 5
Flanged 6
40
·4
38
6½ × 3' × ·36 BA
6½ × 3 × 36 BA
Single 6 × 4 × ·6
Gusset 44 6½ × 3 × 36 BA
·40
Transverse Beam 18 × 4
Face Bar 6½ × 4½ × ·76 OA Single
7 × 3½ × 4 BA to 6½ × 3½ × ·4 BA
4 × 3 × ·4
·40
7½ × 3½ × ·38 BA to 7 × 3½ × ·38 BA
8½ × 3½ × 38 BA to 8 × 3½ × 38 BA
8½ × 3½ × 46 BA to 8 × 3½ × ·46 BA
9 × 3½ × ·44 BA to 8½ × 3½ × ·44 BA
Side Plating ·62 to ·44
9 × 3½ × ·48 to 44 BA
9½ × 3½ × ·44 BA to 9 × 3½ × ·44 BA
10 × 3½ × ·44 BA to 9½ × 3½ × 44 BA
10 × 3½ × 50 BA to ·46 BA
12 × 4 × ·36 Plate 3½ × 3½ × ·4 - 36 Angles
13 × ·4 × ·36 Plate 3½ × 3½ × ·4 × ·36 Angles
Side Transverse 33 × 46
Face Bar 6½ × 4½ × 76 O.A Single
Transverses spaced 8·8 Apart
Shell Attachment 6 × 6 × ·46 with Two
Rows of Rivets 7/8 Dia Spaced 4½ Dias Apart.
Line of Web on Bhd
·46
Centre Bhd Trans. 33 × 4
Face Bar 6½ × 4½ × 76 OA
Line of Web on Bulkhead
40
7 × 3 × ·36 BA
Single 6 × 6 × ·44
7½ × 3 × ·38 BA
7½ × 3 × ·42 BA
8½ × 3 × 38 BA
·42
8½ × 3 × ·42 BA
44
8½ × 3 × 44 BA
9 × 3 × ·44 BA
·46
9 × 3 × ·48 BA
9½ × 3½ × 4 BA
54
9½ × 3½ × 42 BA
5 × 9 × ·6 to 54
6 × 3 × ·4
46
Bottom Transverse 42 × 46
Face Bar 6½ × 4½ × 76 OA Single
Strap
Girder 4
3 × 3 × ·44
Bottom Longitudinals Plate 14 × 4 - 36 Angles 3½ × 3½ × 4 - 36
Bottom Plating ·62 to ·46
Keel 48 × 1·00 to 70

FIG. 9.—MIDSHIP SECTION, ISHERWOOD SYSTEM



Oil Tight Bulkhead. Bulkhead Web

FIG. 10.—BULKHEAD, ISHERWOOD SYSTEM

terminated abruptly, but should be scarphed with the machinery casings. This is the more necessary if the machinery is fitted amidships, and strong beams at that part should be fitted intercostally between the casings, so that the latter may suffer as little discontinuity of section as possible. The centre line bulkhead should be tapered off at its extremities by means of large brackets, top and bottom, or in some other efficient manner.

An interesting example of attention to detail may be seen by a reference to Fig. 6. There the angle connecting the side stringer bracket to the bulkhead is shown extended 6 inches beyond the end of the bracket itself. This is not to be considered as a species of pedantry — the advisability of it was demonstrated by experience derived from several vessels belonging to one of the largest oil-carrying companies in the world. It was found in these cases that persistent failure of the riveting at the extreme edge of the bracket was obviated by this simple expedient— an expedient, it may be added, now almost universally adopted. The short bridge, again, for the same reason, should be a separate erection, built on the main structure, the gunwale bar extending continuously through the same. Precautions are also necessary at the end of this erection. The bulwark should be properly stiffened, and a sufficiently long doubling plate should be fitted, extending beyond the fore and after ends of the bridge. It need hardly be said that the web frame system is continued throughout, and that proper arrangements are made in cofferdams, etc., for maintaining, in these spaces, the strength of stringers, deck plating, centre line bulkhead and sides of expansion trunk, etc.

A statement of general application has been made in the foregoing to the effect that no very fundamental change has taken place in the construction of oil-tank steamers during

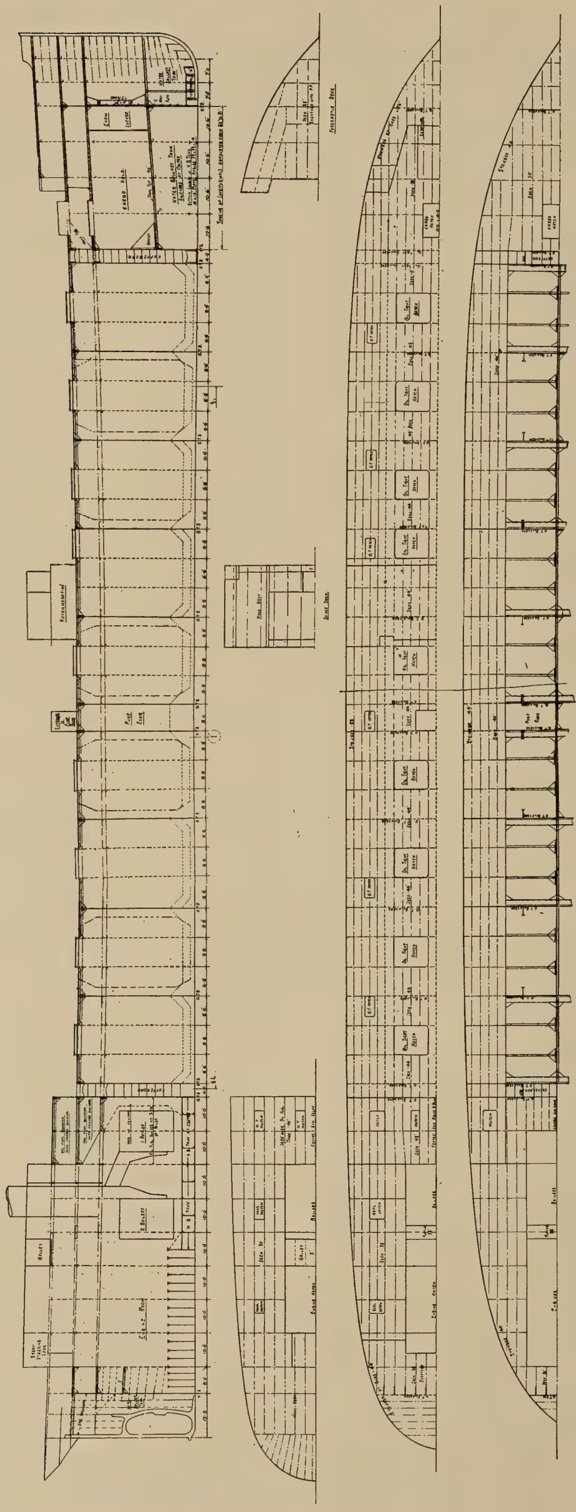


FIG. 11.—PROFILE AND DECK PLANS. ISHERWOOD SYSTEM (PATENT)

recent years, the changes that have taken place being due more to the expansion of size of the vessels than to any definite attempt to model construction on new methods. To that statement, however, there is one striking exception, and no discussion of the structure of oil vessels, however brief, would be complete without a reference to the system designed and patented by Mr. Isherwood, and known as the Isherwood system. Figs. 9, 10 and 11 show 'midship section, bulkheads, profile and deck plans, with scantlings, for a vessel of dimensions 414′ × 54′ 9″ × 32′ 9″. The system of construction is easy to follow. The transverse framework of the vessel consists of the oil-tank bulkheads and a series of strong transverse webs, two of the latter being fitted in each oil tank. The shell plating is supported by a series of longitudinal girders of bulb angle, channel, or built section, which are continued through the transverse webs and cut at the bulkheads and bracketed to them. This principle is adhered to throughout the vessel, as an examination of the decks, transverse and longitudinal bulkheads will make clear. In each instance the external pressure is borne by a series of deep stiff girders, and is distributed among these by a series of intermediate local stiffeners. The deep transverses, upon which the form of the vessel depends, are very strongly constructed and adequately supported, to resist any change of form laterally or otherwise. The designer has been very sensible of the importance to be attached to these transverse girders, and a considerable amount of ingenuity and skill has been spent in attaining strong and stable forms with an economical use of material.

There are many interesting technical questions raised by this form of construction, and some difference of opinion no doubt exists in regard to its merits as compared with those of the system more usually adopted.

There has already been some dis-

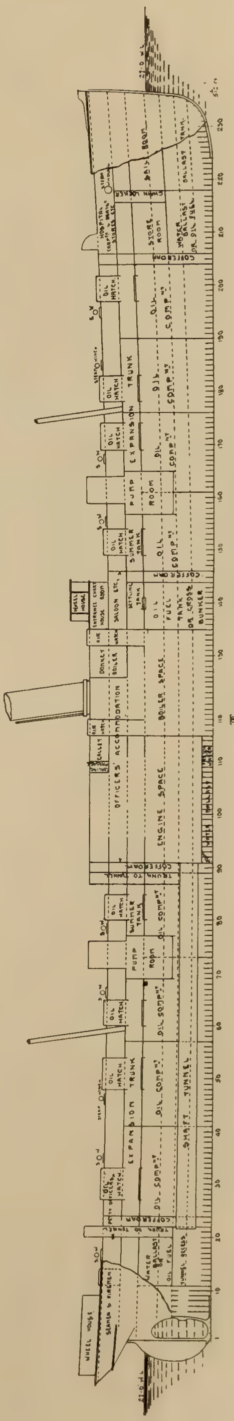


FIG. 12.—PROFILE OF OIL STEAMSHIP NARRAGANSETT

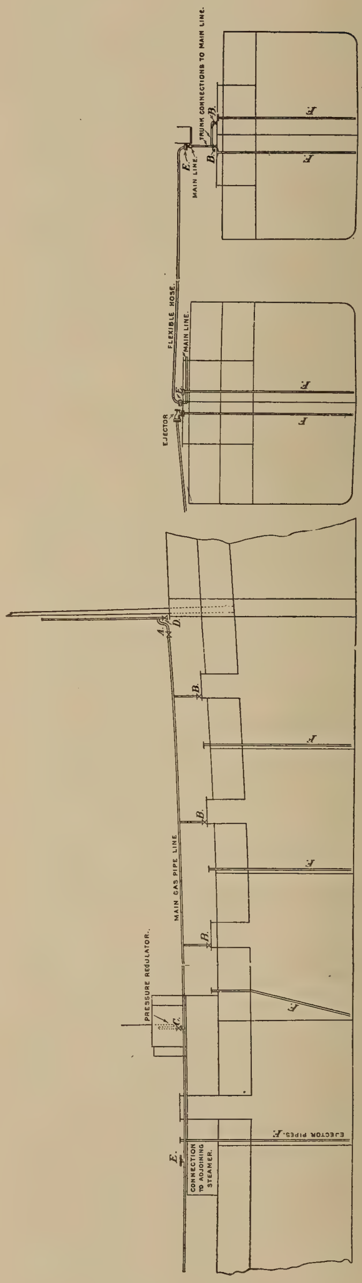
cussion on this point, to which it is, perhaps, not necessary to make any addition except in so far as to draw attention to one or two facts which, in the present writer's opinion, do not appear to have received much consideration.

In the first place, it is no doubt true that there is more longitudinal material in these vessels than in those of the ordinary type; but it is more to the point to observe that the material is disposed *in the proper direction* for resisting structural compressive forces; and it is, therefore, reasonable to consider the shell plating, when stiffened in this way, as having a greater efficiency than when supported by vertical supports in association with a relatively small number of horizontal girders.

In the second place, it is to be noticed that generally two longitudinal girders cross every butt of the shell plating, and the importance of the resultant increased efficiency of butt connection in an oil vessel needs no emphasis. Again, it is to be noticed that the connection of the longitudinal girders to the bulkheads is not so concentrated as in the ordinary ship. In the latter case the large keelsons and side stringers demand very considerable bracket attachment, and the concentration of material at these points has led, no doubt, to an excess of stress there which it is sometimes difficult to provide against. It can hardly be doubted that the greater number of smaller brackets characteristic of the Isherwood system, together with the increased stiffness of the butt connections, render this system very suitable for oil-ship construction.

### LOADING AND DISCHARGING

Nothing, so far, has been said of all that mass of regulation and detail connected with the loading and discharging of oil ships necessary to secure the *safe* transfer of so volatile a cargo. Oils of all densities are carried in these vessels, including benzine, petrol, kerosene



SHEWING CONNECTION TO ADJOINING STEAMER WHEN TRANSHIPPING CARGO AND EJECTOR ON EJECTOR PIPE

*General Arrangement.*

FIG. 13.—GAS FREEING AND CONTROLLING ARRANGEMENT FOR OIL STEAMERS

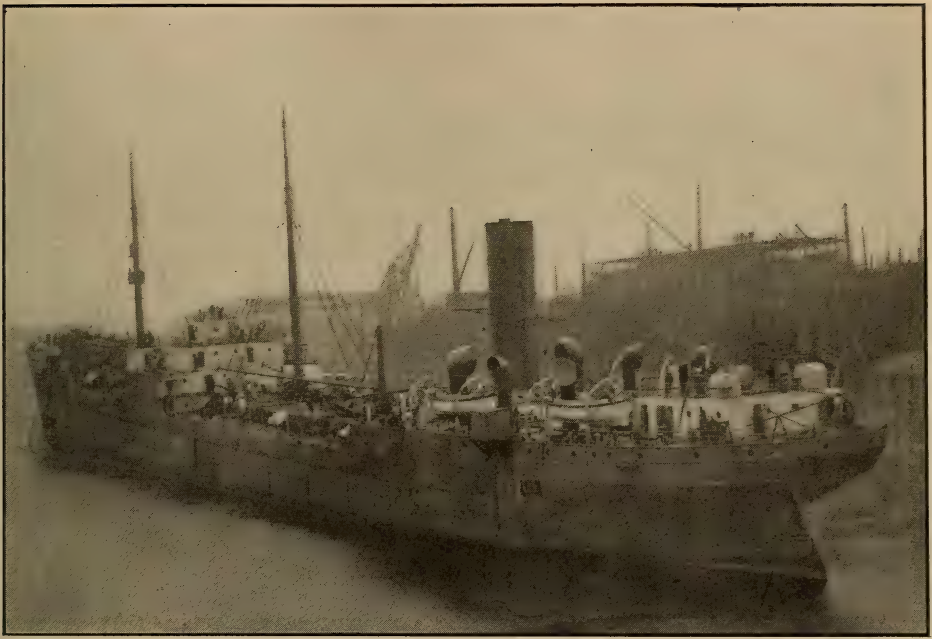


FIG. 14.—STERN VIEW OF THE TANK STEAMSHIP IROQUOIS, BUILT BY MESSRS. HARLAND & WOLFF FOR THE ANGLO-AMERICAN OIL COMPANY. TAKES 450-FOOT BARGE NAVAHO IN TOW

and other low-flash-point oils, some of which commence to vaporize at a temperature a little above 74 degrees Fahr. These oils readily become inflammable, especially if, through some defect, they are sprayed through a leaky pipe or gland. An outstanding example of this occurred in 1886. The vessel, in cargo, had a water ballast tank, and some of the oil (Russian kerosene) had found its way into these tanks. When the ballast tanks were tested, this oil, floating on the surface of the water, was forced, in the form of a very fine spray, through some leaky seams in the tank top. This spray accumulated until the atmosphere in one of the tanks became inflammable, and a species of rapid ignition of the oil-laden atmosphere took place, the effect of which was to cause the death of ten persons. It is, therefore, extremely necessary that all possible care should be taken to prevent, so far as possible, the formation of such explosive mixtures, and to see that, when formed, they do not come into contact with naked lights. The powerful pumps fitted in these vessels (some of which have a discharging capacity of 300 tons per hour) should be accommodated in compartments completely isolated from the machinery space (see Figs. 1 and 12), and these compartments should be efficiently ventilated and no naked lights or electric motors should be allowed therein. Electric light should be used for the lighting of oil vessels, but the single-wire system should be prohibited, in order to avoid short circuiting to the hull. The electric bulbs should be made with double globes when used in spaces in which accumulations of vapour are likely to occur.

The ordinary method of preventing the formation of vapour in the tanks after the cargo has been discharged is by a thorough process of washing, steaming and fanning the tanks. Care is also necessary when loading from shore tanks or from adjoining steamers to see that all vapours and gases generated during the operation are safely conducted away. In Fig. 13 is shown a diagrammatic representation of the gas-freeing arrangement used by the Anglo-Saxon Oil Company, which has replaced the system of steaming out. Exhaust pipes *F,* 3 inches in diameter, are led to about 6 inches from the bottom of the tanks and extended through the deck to at least the top of the expansion trunks. The tops of these pipes are provided with flanges, for the purpose of taking the flange of a steam ejector. The steam flange of the ejector is connected by means of a flexible hose to a winch steam pipe, and the other flange of the ejector is connected to a discharge pipe leading overboard.

The cocks *B, B* on the trucks and the cock *A,* between the main and upright main gas pipe are opened and steam admitted to the ejector, after which the gases are sucked out and discharged overboard. The discharged air and gases are replaced by air passing through the main gas line and the annexed cocks. If the pressure regulator (see figure) shows that the air passing through the gas line is not sufficient, then, but only in that case, the opening of sight glasses or plugs on trunk lids is allowed.

Ships provided with fan engines can often discharge the gases from the tanks through the main cargo pipe line. In such case a steam jet, or the exhaust steam pipe of the fan engine, must discharge into the outlet of the fan, so as to have the gas mixed with steam before being exhausted.

Again, when loading petroleum or any of its products in bulk, all tank plugs and lids, or any other direct openings to the atmosphere from the tanks that are loaded, are kept closed, and the cocks *B, B,* in direct connection with the main gas pipe line, are kept open, to allow all gases and vapours to escape into the air through the main gas pipe line. The pipe leading alongside the mast, the cock *A,* in the main gas pipe line near the upright pipe along the foremast, and the cock *C* to the pressure regu-

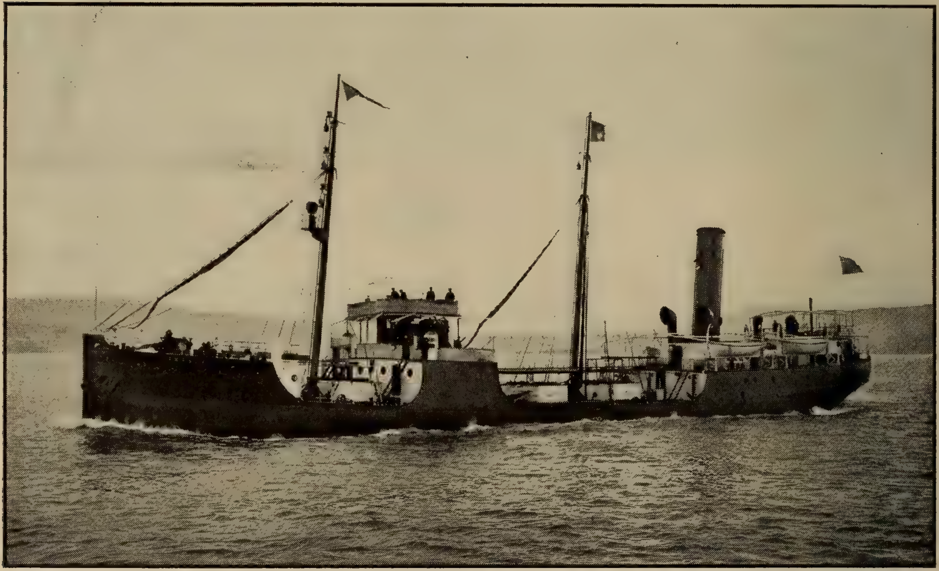


FIG. 15.—TYPICAL OIL STEAMER OF SMALL SIZE, STEAMSHIP IMPOCO (DIMENSIONS 242 FEET BY 40 FEET BY 20 FEET), BUILT BY THE GREENOCK & GRANGEMOUTH DOCKYARD COMPANY

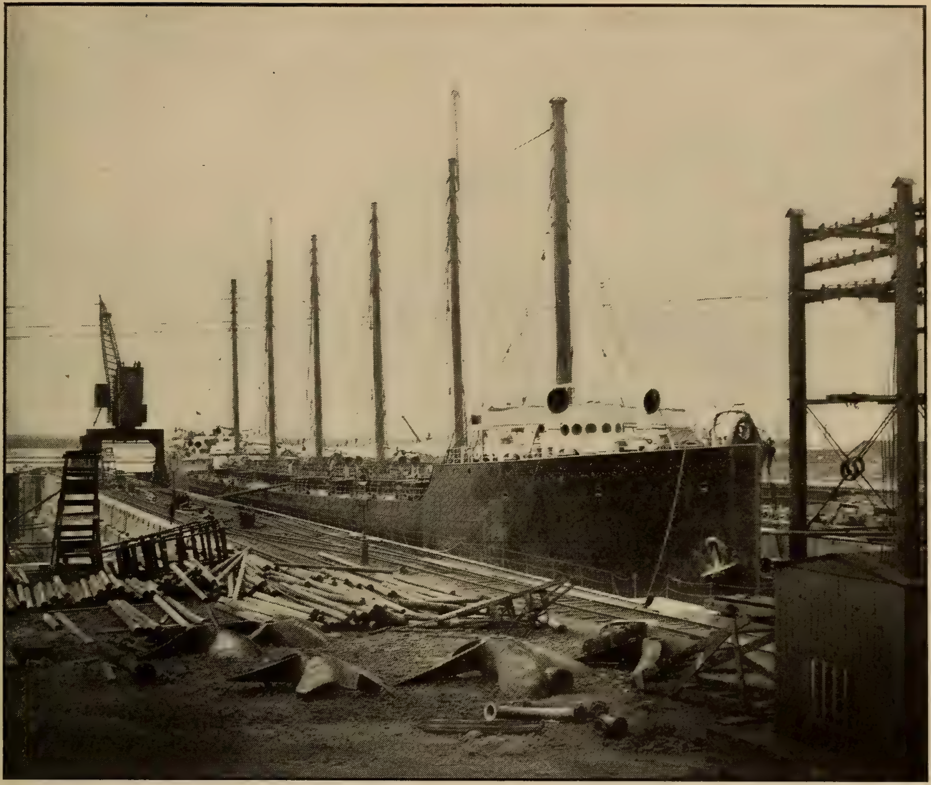


FIG. 16.—OIL-CARRYING BARGE NAVAHOE, BUILT BY MESSRS. HARLAN & WOLFF FOR THE ANGLO-AMERICAN OIL COMPANY, AND TOWED BY THE S.S. IROQUOIS

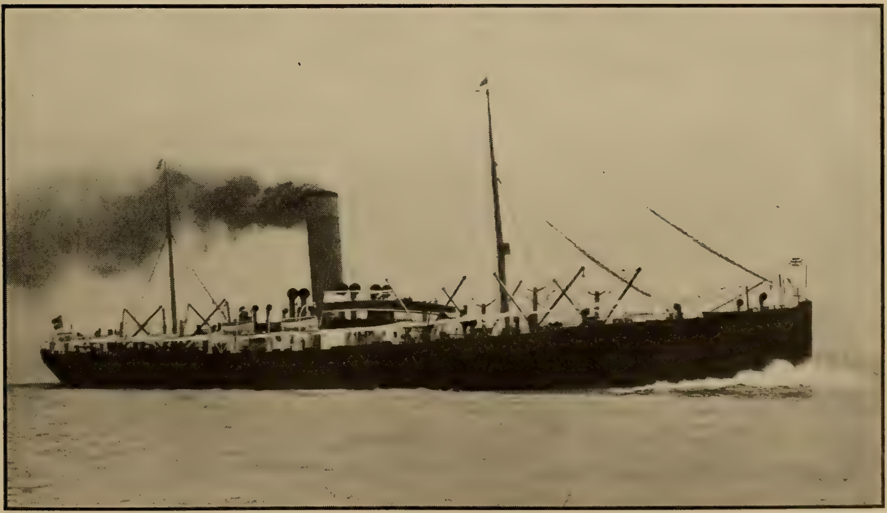


FIG. 17.—STEAMSHIP NARRAGANSETT, THE LARGEST OIL STEAMER. BUILT FOR THE ANGLO-AMERICAN OIL COMPANY, LTD., BY MESSRS. SCOTT & CO.

lator in chart room are, of course, also open.

Before loading is started the vertical gas pipe line is drained of all water and condensed benzine that may have accumulated in this pipe, and this is done by opening cock *D*. As soon as the pipe is found to be drained the loading can be commenced.

During this process the pressure is ascertained by the chart room gas regulator, and, in case any excessive pressure is observed, the steam jet under the vertical gas pipe at *D* is opened, to assist the relieving of pressure.

After loading is finished the cock *A,* in the main gas pipe line to the upright pipe along the foremast, is closed, and all gases that may have accumulated in the upright gas pipe are driven out by means of the steam jet fixed under that pipe at *D* to prevent any danger of fire in case of lightning. To ascertain the height of liquid in the trunks, the trunks are painted white inside, and two sight glasses of ample size are fitted in trunk lids. Taking samples and sounding of tanks must be done through the plugs or movable sight ports in trunk tops.

The rather technical description given in the foregoing represents pretty fairly the precautions adopted generally by those responsible for the safe transport of petroleum, and it will be conceded that they connote a high degree of development in the art of intelligent anticipation. To a considerable extent no doubt the bulk of these precautions is due to the pressure of port authorities and other bodies concerned with the safety of property and the safeguarding of human life, but even in circumstances where this pressure is relaxed or does not exist it is to the credit of all concerned that there is found to prevail an equal anxiety to secure the safety of those who perform the actual operations of transport.

In this article—which is necessarily a very brief and imperfect summary of an important type of naval construction—it might, perhaps, have been not unprofitable, had space permitted, to have projected one's self into the future and, assisted by past experience, to have outlined some of the probable changes that may take place in the construction of oil ships. No one imagines that the present arrangements are stereotyped for all time—in that respect the analogy of the past is irresistible. So far as we can see, the structural changes of the future will consist, not so much in reductions of materials as in the reductions of the number of parts composing the whole, a method which, in many cases, possesses the double advantage of saving both weight and labour. However that may be, it may confidently be stated that any modification of scantlings or any simplification of the structure which can be justified by experience and sound reasoning will have the approval and support of all the controlling interests affected by these changes.

# THE ENGINEER AND THE ENCYCLOPÆDIA

By Henry Harrison Suplee

A SHORT time ago the writer was in the office of an eminent engineer discussing a subject connected intimately with both engineering and finance, and it became desirable to verify some of the fundamental data upon which the undertaking rested. Reference was made to the Encyclopædia Britannica, a set of the ninth edition of which was at hand, only to find that the very full and otherwise satisfactory article upon the subject stopped just short of the period under discussion, and that the desired information was obtainable elsewhere only after a somewhat troublesome search. As a matter of curiosity, upon the appearance of the new eleventh edition of the Encyclopædia the same subject was looked up, with the result that the facts were found brought fully down to date, while, at the same time, additional detailed articles were provided, covering points adding greatly to the value of the inquiry. This experience led to a further examination of the new edition of the Britannica from the viewpoint of the engineer, and the result showed, not only the extent to which such a broad work of reference supplements the specialized literature of engineering, but also the degree to which the work of the engineer has become encyclopædic in character.

When, about a hundred years ago, Tredgold formulated his famous definition of engineering, as incorporated in the charter of the Institution of Civil Engineers, describing it as "the art of directing the great sources of power in Nature for the use and convenience of man," he further added, in elucidation of this broad definition, the words, "as the means of production and of traffic in States for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns."

Notwithstanding the immense developments in engineering which have occurred since these words were written, the breadth of scope then indicated was sufficient to cover the field of the work of the engineer at the present time. The principal difference lies in the great expansion which has taken place in each of the several departments of engineering work over that known as the beginning of the nineteenth century.

Engineering as a "means of production and of traffic in States" covers the whole of manufactures and commerce; "construction of roads, bridges, etc., for internal intercourse" includes, not only the highways of Telford and the aqueducts of Brindley, but the steam railway and its electrical associate; while the "art of navigation by artificial power" shows that steam navigation, even in its infancy, was already in the hands of the engineer.

The civil engineer of Tredgold's day might attempt, at least, to grasp the scope of the profession as a whole, although, even at that period—a period at which the Encyclopædia Britannica had already reached its fifth edition—there were many specialists in the various departments of work. To-day, however, it is wholly impracticable for him to be anything but a specialist; as it has well been said, he must know everything about something and something about everything.

For the one thing which is his specialty, the engineer has his special training, his special text-books and his special works of reference; while for the everything else the principal qualification is that he must know where to look for it.

Among these general subjects there may be grouped the fundamental basic departments in which are included mathematics, mechanics and the principles of physics and chemistry. When to these are added the voluminous records covering the determined properties of engineering materials, not only as to strength for construction, but as to fuel values, for power production, interchanges of energy in power conversion and transmission, resistances of fluids to motion, data of all sorts recording the results of experience in all parts of the world, it will be realized how encyclopædic the demands upon the engineer have become.

It will not do to say that a specialist must limit himself to his specialty. This is altogether impracticable; and, even if it were possible, it would be altogether undesirable to carry specialization to such an extreme, as such a course tends to produce one-sided men, to whom it would become difficult to take a broad view, even of their own specialties.

It is undoubtedly impracticable to unite the specialist training of the modern engineer with the broad, liberal education of the man of general culture,and hence there has arisen the field for general works of reference, combining the highly specialized work of more than a thousand specialists in form for immediate use, and for authoritative quotation, if necessary. More than a hundred years ago the founders of the Encyclopædia Britannica undertook to provide such a work of reference, and to-day the eleventh edition, bearing the imprimatur of one of the greatest institutions of learning in the world, has been completed and placed on sale.

Before considering some of the articles in the new edition which bear especially upon the work of the engineer, it may be interesting to note some of the differences of general treatment of subjects in this new edition and in its predecessors. The first edition was called a "Dictionary of the Arts and Sciences," showing how, in its inception, the work was intended to serve the engineer, and in this, and to an even greater extent in the later editions, there appeared a tendency toward the use of articles which formed in themselves comprehensive essays upon broad subjects, containing within them data and information upon the different parts of the title subject.

With the planning of the eleventh edition, however, this method was retained principally for the very broad titles, such as Ship, Mining, Iron and Steel, and the like, while in most instances the plan of using a much more highly differentiated degree of subdivision has been followed. A general view of a subject is given in an authoritative article under the main title, while a number of independent contributions, prepared, for the most part, by specialists, give the information about the elements of the subject in a form which avoids the necessity for a search through a general treatise. The provision of a separate and very detailed index volume permits the location of these and other articles, apart from the alphabetical arrangement continued from previous editions.

A valuable feature of the ninth edition, expanded materially in the new edition under consideration, appears in the extensive bibliography which is appended to many of the articles. Following out the idea that the engineer, especially in subjects lying somewhat outside of the domain of his own specialty, desires to know where to find the last word upon some other man's specialty, the opportunity for extended reference is given by placing before him such a complete list of books relating to the subject that he may, without material delay, consult the sources from which the encyclopædia article has mainly been derived, and be enabled to add to the authority of the contributor the statements of others of equal weight. In this respect the encyclopædia contributes materially to the efficiency of its users by preventing the expenditure of much valuable time looking up books and authors, and thus doing over again work which has really been done once for all by others.

The three fundamental divisions upon which the applied science of engineering must always rest, then, may be taken as mathematics, physics and chemistry.

A famous civil engineer, noted both for his works and for his writings, wrote, many years ago: "Comparatively few engineers are good mathematicians; and, in the writer's opinion, it is fortunate that such is the case, for Nature rarely combines high mathematical talent with that practical tact and observation of outward things so essential to a successful engineer."

Nevertheless, the engineer must be continually making use of relations involving mathematical expressions, and the engineer who does not have the rigid logic of mathematics back of his work cannot expect to carry on his work with that confidence and assurance which are necessary to the achievement of great things. It has been said that the only thing necessary is for the engineer, architect or great industrial corporation to have a "tame mathematician" employed in a back room, to work out the questions submitted to him. However this may be, it is even more necessary to have at hand some authoritative compendium of the basic principles of the correct relations of quantities for immediate reference and comparison. This is especially true of the higher mathematics, which, even in their more practical applications, are hardly given sufficient active use to permit the engineer to keep himself bright in their direct applications. Here the mathematical articles in the encyclopædia are immediately available, and direct reference may be made to the general article upon Mathematics, by Mr. A. N. Whitehead; the valuable treatise upon the Infinitesimal Calculus, by Professor A. E. H. Love, and to the articles upon Probability, by W. F. Shepard, and Interpolation, by F. Y. Edgeworth.

In this connection attention may be directed to the development which has been made of late in the construction and application of mechanical devices for integration. These have grown from the simple area planimeter of Amsler to the remarkable devices, both of this pioneer and others, which enable many of the more difficult problems in integration to be performed mechanically, thus adding to the art of graphical computation the one element lacking to enable it to cover broadly the field of direct computation.

In addition to the contributions in the encyclopædia in the domain of fundamental mathematical principles, there are a number relating to engineering subjects in applications of these principles. Among these we may mention the extension and revision, by Professor Helmert, of the important article upon the Figure of the Earth, originally prepared by Col. A. R. Clarke for the ninth edition of the encyclopædia.

The basic subject of physics forms another of the fundamental departments of applied science for which the engineer must naturally depend upon the encyclopædia for immediate reference, and in this field the Britannica has well maintained the high position which has hitherto held. In the ninth edition the names of Lord Kelvin, Clerk Maxwell and Lord Rayleigh gave assurance of the high degree of precision offered in their respective fields of work, and the subjects treated by these older masters have been most conservatively handled in the new edition. Lord Kelvin, before his death, selected Professor H. L. Callendar to revise the article upon Heat and Professor A. E. H. Love to deal with that on Elasticity. Lord Rayleigh continues as a contributor to the eleventh edition, and also as a reviser of some of the articles originally written by the late Clerk Maxwell. By dividing the subject of physical science into (1) Nature, Structure and Properties of Matter, Aether, Energy; (2) Sound; (3) Heat; (4) Light; (5) Magnetism and Electricity, a convenient classification was obtained, and in all of these there appears such basic information, in the light of the latest researches, that the engineer may use them with confidence.

The third fundamental division of applied science is that covered by the comprehensive title of Chemistry, and although much of this field belongs to other departments of work than that included strictly in engineering, yet the scope of chemical engineering is continually extending.

Taking up more in detail some of the articles more especially within the domain of the engineer, we may at first recall some of the really notable treatises which have been continued, in revised and extended form, from the ninth edition, together with some of similar character now seen for the first time in the present edition.

Thus, the article upon the broad subject of the steam engine, by Professor J. A. Ewing, which appeared as a separate treatise in a portly volume after it had been published in the ninth edition of the Britannica, is yet in the eleventh edition, revised and extended by the author. Professor Unwin's notable treatise upon hydraulics, which formed so important and authoritative a contribution to the older edition, has been brought down to date by the same able hand. To these have been added new articles dealing in similar fundamental manner with the details of the generation of power, although, for the most part, the newer contributions have been divided between several authors, in accordance with the determined policy of further specialization.

The subject of Fuel, now divided in actual practice into solid, liquid and gaseous, is similarly divided in treatment in the encyclopædia, each division being in the hands of an eminent specialist. Thus, solid fuel is discussed by H. Bauerman, both under this specific title and under the title of Coal; while Sir Fortescue Flannery treats of liquid fuel, in connection with which the article by Mr. Dugald Clerk upon oil engines will naturally be associated. Professor G. Lunge covers the title of gaseous fuel in a most competent manner, and these articles practically indicate what we have called the side of chemical engineering of the encyclopædia.

In applied physics the most important subjects naturally fall into the domain of electricity, and while the practicing electrical engineer will naturally have his own experience and special works of reference for his particular service, the extent to which electricity enters into general engineering work renders this portion of the encyclopædia especially useful to the specialist in other lines.

The articles upon the dynamo by Mr. C. G. Hawkins and upon electric motors by Dr. Louis Bell form each considerable treatises upon these subjects, while the subject of electric transmission of power, also by Dr. Bell, forms a section of the general article on power transmission. The other departments of power transmission are treated by Professor W. E. Dalby, so far as mechanical transmission is concerned, while Mr. E. B. Ellington discusses his especial subject of hydraulic transmission of power, and Mr. A. deW. Foote covers pneumatic transmission.

Two of the probably most extensive individual treatises in the present edition of the Britannica come from the pen of the same author, Sir Philip Watts, Chief Constructor of the British Admiralty, these covering the article Ship and the companion title, Shipbuilding, these being comprehensive works upon their respective subjects. Apart from the historical and economic side of the subject, these articles naturally cover details of design, of structural work, and of the great subject of machine tool applications to shipbuilding—a department of engineering work of ever-increasing importance. The tabulated statement of the development of steamship construction is an especially interesting illustration of the growth of this department of industry, the continually increasing displacement, length, speed and powering following a progress almost uniform in its advance.

Another example of the department of chemical engineering appears in the papers discussing the isolation and preparation of some of the important metallic materials of engineering, this including, again, some of the longer treatises associated with the scope of the Britannica.

Professor Henry M. Howe's article on iron and steel covers the subject, from the discussion of the distribution of the iron ore supplies of the world to the latest developments of the electric furnace for the production of steel of the highest grade; while the papers of the late Sir W. C. Roberts-Austen and Mr. F. H. Neville upon alloys takes up the subject of the modern alloy steels and the science of metallography, upon which so much of our modern knowledge about the physical structure of alloys depends.

One of the modern departments of the engineering specialist is devoted to artificial illumination, and the extent to which this subject has become specialized appears in the fact that a society of illuminating engineers enjoys an active and interested membership. In the Britannica, this department of work is well covered by such well-known specialists as Professor Vivian B. Lewes, as regards lighting by gas and acetylene, and by Professor Fleming and Mr. Emil Garcke for electric lighting, these articles enabling the general engineer to have at hand the latest developments in this field for consultation and reference.

Although the subject of mining is really the broad field of a large department of engineering work, it naturally demands full treatment in such a work as the Britannica; and while there is a long general article by Professor Munroe, of Columbia University, the details of mining engineering, such as boring, blasting, shaft-sinking, and the various results of mining work, are covered by separate and specialized contributions.

The work of the civil engineer, including such great departments of engineering work as railways, bridges, docks, harbours and river improvement, is given very full treatment in the encyclopædia, and among the contributors under these titles the names of Professor Unwin, Professor Dalby, Mr. Howard A. Carson, Mr. Vernon Harcourt and Sir C. Scott-Moncrieff may be mentioned. These, and similar eminent contributors, have placed the various departments of what has been termed "statical" engineering in shape for use, not only by the general reader, but by the engineer who requires the services of just such specialists to aid him as auxiliaries to his own specialty.

A very important fact in connection with the present appearance of the eleventh edition of the Encyclopædia Britannica, not only to the engineer, but to the general reader, appears in the fact that the entire work has been prepared for publication as a whole. The present writer well remembers the long years which elapsed between the appearance of the successive volumes of the ninth edition, and it requires only a consultation of the earlier and later volumes of that great work to realize the changes which took place during the period in which it was gradually placed in the hands of its subscribers.

The present time is one of even more rapid changes than took place in the years between 1875 and 1889, and any work of general information covering more than a dozen years in its appearance could not fail to possess a most unequal value in its various parts. It is true that the foundations of knowledge do not change, but the manner of the presentation of even the fundamental facts of thought and activity become modified; and in a work such as we are now considering it is most desirable that unity of plan should be followed by unity in execution. That this has been accomplished in the case of the Britannica is a matter for congratulation to the University of Cambridge, to the editors, and, most of all, to the purchasers. As it stands, the work is representative of an epoch, standing for the sum of general and special knowledge in the first decade of the twentieth century, and thus forming a record of the status of the civilized world at a definite period of time.

To the engineer, of all men, this fact is of particular significance, since the present century is especially the age of the engineer. Engineering work is entering into all departments of life and industry, and the extent to which engineering devices, methods and conceptions have insinuated themselves into the inmost thoughts of the community is scarcely realized, even by those who are most nearly affected.

There are few establishments into which the slender wire does not bring light, heat, power and intelligence from some centre of mechanical conversion of energy. Few men, women or children can go far from their homes without unconsciously calling upon the engineer for transport or for communication. In the business building, and even in the home, the elevator calls in the electric current, the hydraulic service or the winding engine. Every city is dependent upon the great works of the engineer for its supply of pure water and for relief from its wastes and accumulations. The food supply of nations is controlled by mechanical appliances, from the seed time, through cultivation, to harvest, transport, storage and preparation for use.

One of the characteristic features of modern applied science appears in the possibility of sudden changes which may appear, and against which provision should be made. The successful manufacturing business of to-day may find some new process, improved tool or changed market to-morrow which shall exercise a profound and unforeseen influence upon its entire conduct. No familiarity with details can aid in the handling of such an emergency, and yet it is the function of the engineer to meet just such conditions. The man of wide resources and of broad general view is called upon to exercise both judgment and information in such cases, while the mere specialist may see his single specialty fading away and becoming obsolete before his eyes.

Under no circumstances, however, can the fundamental principles of science, upon which all engineering industries are based, lose their value and importance, and it is by the application of these basic principles that all emergencies must be met.

A common error is found in the usual assumption that the development of some new way of doing an old thing necessarily means the entire abandonment of the old way. In many cases there is room for both the old and the new industry, even if the older one may have to be diverted into some new field or application. The extent to which electric lighting was assumed to supplant gas was measured by the temporary fall in the price of shares in gas lighting companies when illumination by electricity was first introduced. To-day, however, there is more gas manufactured than ever, and its efficiency as an illuminant is greatly increased, while its application as fuel has been enormously extended. At the same time, the entire business of electric distribution of light, heat and power has grown to its present magnitude by the side of the expansion of its predecessor and rival. This is but one illustration out of many. The steam turbine has not killed the steam engine; on the contrary, its success has stimulated the manufacturers of the older machine to renewed activity and effort. The great progress of the combustion engine appears both in the new markets which it is creating for itself and in the impulse which it is giving to the improvement of the steam engine.

These changes and expansions, therefore, do not necessarily lead to the overthrow or sudden breakdown of mechanical industries, but they may be cause of serious changes in the opportunities of individuals. It is in just such unforeseen modifications that the weakness of extreme specialization appears. Usually it is the man of wide information, either personal or available, who is called upon to meet these crises. The man who knows but one thing has to make way for the man who knows many things, unless, by the prompt and effective use of just such a mass of classified knowledge as is furnished by the encyclopædia, the specialist has armed himself for the unexpected, which usually happens.

Lord Brougham once defined science as "knowledge reduced to a system." This might well be taken as a definition of the Britannica without modification. With such a mass of scientific knowledge at his back, the specialist ceases to be a specialist only, and becomes an all-around man of science, equipped to cope with emergencies all the more effectively because of the mental training which concentration upon a specialty has given him.

Another service which the Britannica may render to the engineer appears in the supply of general data and information for the preparation of reports and abstracts of operations to be submitted to the laymen for examination and opinion. The specialist who has placed in his hands some investigation upon the results of which the conduct of a great commercial enterprise may depend may not be too technical in the presentation of the facts and conclusions; neither should he appear unfamiliar with the relations of the subject to other departments of industry. The report which is to convince men of affairs must be not only correct, but it must be couched in the language in which they are habitually formulating their plans, and it should indicate the connection of the matter to other co-ordinated questions.

It has been well said that "theory takes into account all the conditions which can be ascertained, but practice is obliged to take into account all the conditions there are." The successful engineer is he who uses the recorded work of his predecessors and associates to aid him in grasping all the conditions there are; or, failing such a comprehensive grasp of the question in hand, at least avoids the mistake of assuming that he has ascertained all the conditions.

If the present-day world were obliged to go back to the conditions which existed at the time of the appearance of the first edition of the Encyclopædia Britannica — a date which, curiously enough, coincides precisely with the date of the original patent of James Watt for the steam engine—it would be plunged in comparative darkness, held in bondage of obstruction to transport, and smothered in the silence of impediments to communication.

The engineer has been almost

wholly responsible for the difference between those days and the period in which we are now living. The year which saw the simultaneous appearance of the first edition of the Britannica in Edinburgh and the first engine by Watt in Glasgow was the year which marked the beginning of the transformation. The appearance of the second edition coincided with the American Revolution, as that of the third edition came with the Revolution in France. The fourth edition began with the nineteenth century—that "wonderful century" which, as Alfred Russel Wallace has said, surpassed all the ages which preceded it.

In the period which preceded the appearance of the first edition of the Britannica it was practicable for a single cultivated mind to grasp practically the entire sum of human knowledge. During the period which has followed the work of the men who devoted themselves to the direction of the great sources of power in Nature to the use and convenience of man so extended the activities of the entire world that it soon became evident that no man could expect to know more than a small portion of the ever-widening realm of knowledge. The encyclopædia became a necessity; how great a necessity no man realizes more fully than he to whom this immense expansion is mainly due—the engineer.

Combining the feature of dictionary, gazetteer, general reference book, biographical dictionary and collection of technical and literary treatises, the Britannica, with its 40,000 articles and its more than 40 million words, represents, more fully than any other one publication, the present status of the human race.

# TRANSPORTATION COST BY CANAL AND RAILWAY

BUREAU OF RAILWAY ECONOMICS

IN the wide discussion regarding canals and inland waterways in the United States during the past few years, little attention has been directed to the total cost of canal transportation. The term "total cost" is here used to cover not only the immediate cost of conveying goods, but also the cost of maintenance of the canal, cost of ordinary repairs, and fixed charges, dividends and depreciation charges, if any.

Freight rates via the Erie Canal are frequently contrasted with freight rates via railway, but as they comprise only the immediate transportation cost—that is, the direct charge for conveyance alone—they are hardly comparable with railway rates, which provide the revenue from which must be met not only the cost of conveyance, but also fixed charges upon the capital invested in the plant and the expense of maintenance of plant and equipment. All tolls on New York State canals were abolished in 1882, and the canals since that date have been maintained and operated at the expense of the State for the free passage of boats. Thus the only charges made against a shipper of goods by canal are those of the boatman who handles the goods, and these charges do not help to pay for the maintenance of the canal or for repairs. From the shipper's point of view a canal rate of two mills a ton is unquestionably preferable to a railway rate of six mills, if speed and convenience of handling are not as important to him as a low rate. It will be shown, however, that from the broader point of view of the community the railway rate, although apparently higher, may not actually be so. The maintenance and fixed charges on the canal, which are borne by the community, may amount to more than the difference of four mills per ton-mile, which is the immediate saving to the shipper. This raises the question whether the burdening of the entire community for the benefit of the shippers, who constitute only a portion of it, is justified. But leaving this question aside, a fair comparison of the cost of transportation by canal and by rail should certainly be of aggregates that include every element in those respective costs.

This study is an effort to estimate the total cost of transporting a ton of freight one mile on the Erie Canal at the present time, and to compare that cost with typical or average railway ton-mile freight receipts. To reach an estimate of transportation cost on the Erie Canal, it has been necessary to ascertain three items in that cost: first, fixed charges on the canal, or cost of capital; second, cost of maintenance; third, immediate cost of transportation. The sum of these three items will give, fourth, the total cost of transportation.

The Erie Canal is a product of State enterprise, paid for from funds obtained, for the most part, through loans made by the State of New York. These loans have, to a large extent, been repaid, partly out of the revenue from the canal and partly from sinking funds established and built up through taxation. Because of this liquidation of the canal debt, interest charges paid by the State

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[1] From Bulletin No. 21, Bureau of Railway Economics, Washington, D. C.

on behalf of the canal have till recently been comparatively small. The canal represents, however, the investment of the people of the State of New York in a transportation plant, just as a railway represents an investment on the part of its stockholders and bondholders. In ascertaining canal transportation costs that shall be strictly comparable with railway transportation costs, it will therefore be necessary to arrive by some method at the physical value of the Erie Canal to-day and on that value compute fixed charges, representing interest on the investment and depreciation.

But how estimate the value of the canal? There are two ways: first, to take the total cost of construction and permanent improvements to date or, second, to make a physical valuation of the whole canal property. Clearly, it is impossible to value the property without a careful appraisal. The statement so frequently made during the New York State canal campaign of 1903 that the Erie Canal, as it stood, was worth more than the total amount expended on it since its inception, cannot be accepted without proof, especially as value depends so definitely on performance. The canal is not of value except as a canal, and, as a canal, is valuable only in proportion to the service rendered by it. It is feasible, however, to ascertain the total cost of construction and improvement of the Erie Canal as a measure of its present value.

Complete official data showing the cost of the Erie Canal to 1905, the year when work on the new barge canal was commenced, are not available. The canal auditor of the State of New York, in his annual report for 1882, stated the total cost to that year as $49,592,000. From 1882 to 1905 a number of special appropriations were made by the New York Legislature for the purpose of improving the State canals, chiefly by deepening the channels and lengthening the locks. Among these appropriations was one of $9,000,000, made in 1895 for the purpose of increasing the lock capacity and depth of the Erie, Champlain and Oswego Canals. Of the amounts spent under the latter appropriation up to July 15, 1898, more than five-sixths, or $6,787,000, was expended on the Erie Canal.[2] What proportion of the other appropriations was applied to the Erie Canal it is not possible to ascertain, but the share of that canal in the total was considerably over one-half. The Greene committee estimated that the cost of constructing and improving the Erie Canal down to 1896 had amounted to $56,165,000.[3] It is probable, therefore, that Hepburn's estimate of $57,600,000[4] as the total cost to 1905 is well under the truth. On the basis of $57,600,000, the cost of the Erie Canal up to 1905 was $163,600 a mile, which may be compared with the cost of road per mile of the four main trunk lines between Buffalo and New York: the New York Central, the Erie, the Lackawanna and the Lehigh Valley. The cost of road per mile of these railways, according to the reports made to the Interstate Commerce Commission for 1905. was as follows:

| | |
|---|---|
| New York Central | $181,250 |
| Erie | 292,970 |
| Lackawanna | 90,240 |
| Lehigh Valley | 60,490 |
| Average | $212,716 |

Canal construction is far more expensive than is ordinarily appreciated, as is seen from the foregoing comparison.

It will now be possible to estimate the total cost of transportation on the Erie Canal, made up of three items already enumerated: cost of capital, cost of maintenance and immediate cost of transportation.

First. *Cost of Capital.*—Taking 4 per cent. as the rate of upkeep on the Erie Canal—an item intended to provide for interest charges and for extraordinary repairs and depreciation—and using a conservative estimated value of but $55,000,000 for the canal at the present time, instead of the $57,600,000 cited above, we have a total annual fixed charge of $2,200,000. This amount will be apportioned per ton-mile of canal traffic in 1909 in a later paragraph.

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[2] Report of Committee on Canals of New York State, 1899, page 162. This committee is commonly known as the Greene committee.

[3] Report, page 153.

[4] A. Barton Hepburn: Artificial Waterways and Commercial Development, page 100.

Second. *Cost of Maintenance.*—The cost to the State of New York of maintaining the Erie Canal in 1909, according to data contained in the annual report of the Superintendent of Public Works of that State,[5] amounted to $672,105. This amount is ascertained by adding to the $500,551 of operating expenditures and ordinary repairs a proportion, obtained by pro-rating on the basis of comparative expense, of the total general and division expenses of the canals of the State. This added charge covers administrative and supervisory expenses. The reduction of this item of maintenance to a ton-mile basis will be made shortly.

Third. *Immediate Cost of Transportation.*—This is composed of boatmen's charges for conveyance. Canal boat rates vary considerably with the season, the condition of traffic and the attitude of the boatmen. There are so few owners of boats on the Erie Canal at present that they can regulate boat rates practically at will. The actual cost incurred by the boatmen in conveying wheat on the Erie Canal was estimated by the Greene committee of 1889[6] at 1.75 mills per ton-mile. This estimate covers interest at 5 per cent. on investment in boats, all expenses for wages of boathands, and repairs, deterioration and insurance on boats, without allowance, however, for profit to the boatmen. The average rate on wheat from Buffalo to New York during the season of 1909 varied from 2.07 mills per ton-mile[7] in July to 3.33 mills in October and November; and on corn from 1.87 mills to 3.07 mills. The average for the season was 2.60 mills per ton-mile on wheat and 2.35 mills on corn. These rates differ by less than one-half of 1 per cent. from the average of the rates reported by the Superintendent of Public Works for the years 1900 to 1909, and may therefore be considered as representative. The foregoing rates and estimate apply to grain only. For all commodities moved on the canals of New York State the average ton-mile rate between 1903 and 1907 was 2.00 mills.[8] An estimate of 2.00 mills for the average ton-mile rate on the Erie Canal to-day would, therefore, seem to be a reasonable one. This represents the immediate charge for conveyance.

Fourth. *Total Cost of Transportation.*—Of the three components of transportation cost so far discussed, two have been gross amounts for the Erie Canal as a whole, while only the last is expressed in terms of ton-mile traffic. To reach a figure of total cost per ton per mile it will be necessary to ascertain the total ton mileage of the traffic on the Erie Canal in 1909 and reduce the first two amounts to a ton-mile basis.

Unfortunately, no ton-mileage figures are reported for the canal traffic in New York State at the present time. It will be necessary to make an estimate for the Erie Canal based upon the reports of tonnage carried. The total number of tons of freight carried on the Erie Canal in 1909 was 2,031,307. What proportion of this was through freight was not reported, but if the proportion was the same as in 1908, then 436,731 tons consisted of through freight and 1,594,576 tons of way freight. If we assume that way freight was carried an average of half the length of the canal, or 176 miles—which is a liberal assumption—and that all the through freight was carried the whole length of the canal, or 352 miles, we have a total ton-mileage of 435,000,000 for 1909.

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[5] Report for 1909, pages 31-39.

[6] Reeport of Committee on Canals of New York State, 1899, page 57.

[7] Ascertained by reducing the through rate per bushel to a ton-mile basis.

[8] Hepburn, page 104.

On the basis of 435,000,000 ton-miles of traffic in 1909, the fixed charges or cost of capital, $2,200,000, were equivalent to 5.06 mills per ton-mile; and the cost of maintenance, $672,105, to 1.55 mills per ton-mile. The total cost of transporting one ton of freight one mile on the Erie canal in 1909 was made up, then, of the following items:

| | Mills. |
|---|---|
| Cost of capital | 5.06 |
| Cost of maintenance | 1.55 |
| Immediate cost of transportation | 2.00 |
| Total | 8.61 |

Thus there is obtained a total charge for canal transportation of 8.61 miles per ton-mile directly comparable with a railway freight rate. What railway freight rate or receipt shall be quoted in comparison with this 8.61 mills of canal cost? By the four principal railways running between Buffalo and New York freight receipts per ton-mile in 1909 were reported to the New York State Public Service Commission as follows:

| | Mills. |
|---|---|
| New York Central | 6.2 |
| Erie | 6.1 |
| Lackawanna | 7.4 |
| Lehigh Valley | 6.4 |

Whichever one of these various railway average receipts per ton-mile be taken, the cost of transportation on the Erie Canal will be found to exceed it by from 16 to more than 40 per cent. Even when compared with average railway receipts for the whole United States, the Erie Canal cost of transportation is considerably the higher. Thus, average freight receipts per ton-mile in 1909 for all the railways of the United States amounted to 7.63 mills, as compared with 8.61 mills of cost on the Erie Canal. For specific commodities the result is similar. The Interstate Commerce Commission reports that average railway freight receipts in 1909 for four of the commodities which make up a large part of the Erie Canal traffic were as follows:

| | Mills. |
|---|---|
| Grain | 6.11 |
| Lumber | 7.70 |
| Anthracite coal | 6.03 |
| Bituminous coal | 5.12 |

None of these averages, it will be observed, is as high as the average cost of transportation via the Erie Canal.

All this is true despite the very conservative estimates in making up the figures for the Erie Canal—and this conservatism is worthy of special emphasis. Thus the ton mileage estimate used is probably too large, and the ton-mile canal rates based on that estimate are correspondingly low. In the opinion of the statistician to the New York Superintendent of Public Works the average length of haul of way freight over the Erie Canal is not over 100 miles, yet the estimate here adopted is 176 miles. Again, 4 per cent. is a conservative rate for depreciation and interest. The stock and bonds of all the railways in the United States in 1909 had an average dividend and interest rate alone that exceeded 4 per cent., and an allowance of 4 per cent. for both interest and depreciation charges in connection with the Erie Canal is, in comparison, clearly a minimum. Finally, the estimate of value of the Erie Canal property used in the computation is considerably lower than the estimates of the Greene committee and of other careful students of canal history.

Another fact that must be recognized in a comparison of railway and canal transportation costs is that the grade of goods shipped via canal is far inferior to that shipped via railway. The goods sent by canal are bulkier, coarser, of less value, and naturally are carried at a lower average rate. Of the tonnage carried over the New York canals in 1909, for example, nearly a third (31.8 per cent.) consisted of stone, rock, lime and clay; another third (36.6 per cent.) consisted of coal, iron ore, pig iron, boards, timber, pulp wood and wood pulp; while a fifth (21.2 per cent.) was made up of grain, ice, and salt. It is clear that an average railway freight rate based only on such articles as were carried by the Erie Canal in 1909 would be lower than the average freight rate on all articles carried by railways. The computations made above, therefore, result in an average canal rate lower than if the grade of articles carried by the canal averaged as high as on the railways. Notwithstanding this, the average canal rate, as has been shown, is actually higher than the highest average railway freight receipt quoted.

One cause of the high cost of transportation on the Erie Canal is the fact that the canal remains idle so large a part of each year. The average length of the canal season is 223 days, or about 7½ months. During the remainder of the year the plant and the boats lie practically idle, although all of the general and many of the maintenance expenses continue without change. In the estimate of the Greene committee regarding the actual cost of transportation allowance was made for this period of idleness by computing all expenses on the basis of only seven round trips a year—a full load on the down-trip and a third of a full load on the return. But in estimating depreciation and interest charges no such allowance can be made—the plant is in existence and must be maintained, whether in operation or not. Whether or not this long period of idleness each year on the part of the canal is responsible for a large or a small part of the greater cost of canal as compared with railway transportation, it is an inherent feature of canal business in the State of New York and must be taken into account when comparing its canals and railways.

This study has been limited to the Erie Canal of to-day, all the statistics being based on past performances of record. The people of the State of New York are now engaged in spending more than $100,000,000 in the enlargement and improvement of the canal system of their State. What the total cost of transportation on the new barge canal now emerging from the old Erie will be no one is in a position to know definitely. The Greene committee of 1899 estimated the cost of the barge canal at about $60,000,000. Already more than $100,000,000 has been voted for this purpose, with the possibility that another $19,000,000 will be required for terminals. The Greene committee also made an estimate of the cost to the boatmen of conveying goods through the barge canal corresponding to their estimate of 1.75 mills on the old Erie referred to in an earlier paragraph. The estimate on the barge canal was 0.52 mill. Whether this estimate will prove to be approximately accurate, or whether time will show it to have been too low, no one at the present time can tell, as no facts exist on which even an approximation may rest. It is clear, however, that, having added so greatly to the cost of the canal, rates must be much lower, or volume of traffic far greater, or cost of maintenance and repair lower in proportion to volume of traffic—one or all of these must result before the total cost of transportation on the new Erie will fall to or below the level of the average railway freight rate.

It seems clear, then, from the data presented in the foregoing pages that the transportation of goods on the Erie Canal at the present time is a more expensive process, considered from the broadest point of view, than on the typical or average American railway, whether or not that railway be one that competes directly with the canal.

# THE DEVELOPMENT OF THE AMERICAN NAVY

PROBABLY the largest aggregation of American naval vessels which has yet been gathered at any one point was that represented by the fleet which was reviewed by the President of the United States and the Secretary of the Navy in the harbour of New York at the beginning of November of this year. There have been other gatherings of naval vessels in various American ports at earlier dates, which enable comparisons to be made and the development of the naval strength of the country to be realized, and the following figures will be found of interest to engineers and laymen alike:

In the international naval review held at New York in March, 1893, there were 14 American naval vessels of all classes, with an aggregate displacement of 39,436 tons.

In September, 1906, President Roosevelt reviewed the Atlantic fleet at Oyster Bay, and there passed before him 45 vessels, with displacements aggregating 279,612 tons.

During the Jamestown Exposition there was mobilized at Hampton Roads, in June, 1907, a fleet of 33 vessels, displacing 285,251 tons.

When the Atlantic and Pacific fleets met at San Francisco in May, 1908, they combined a total of 46 vessels, displacing 407,924 tons, and in September, 1909, at the Hudson-Fulton celebration 43 vessels were assembled, with a total displacement of 316,762 tons. This latest review at New York included 102 vessels of all classes, displacing about 577,285 tons, which does not include the eight submarines, of which no figures were available. Concurrently at Los Angeles a review was taking place of 24 vessels of 116,000 tons displacement, giving a grand total of 126 vessels, displacing 694,000 tons. Perhaps the most striking evidence

THE ATLANTIC FLEET IN THE HUDSON

of our progress is that, of all the vessels in the New York review, the only ones that were a part of our navy at the time of the Spanish War were the battleships *Iowa, Indiana* and *Massachusetts;* the gunboats *Castine, Nashville, Marietta* and *Petrel;* a few of the small torpedo boats, and some of the fleet auxiliaries.

### AN ANALYSIS OF THE ATLANTIC FLEET

The following table shows the number of vessels of each class in the Atlantic fleet and their total displacement:

| | | Tons. |
|---|---|---|
| 24 | Battleships | 366,864 |
| 2 | Armored cruisers | 29,000 |
| 2 | Cruisers | 6,950 |
| 22 | Destroyers | 15,463 |
| 16 | Torpedo boats | 2,994 |
| 8 | Submarines | .... |
| 3 | Tenders to torpedo fleet | 8,466 |
| 4 | Gunboats | 4,737 |
| 9 | Miscellaneous | 40,733 |
| 8 | Colliers | 93,938 |
| 1 | Oil tanker | 6,159 |
| 3 | Tugs | 1,981 |
| 102 | Vessels of all classes | 577,285 |

Exclusive, again, of the submarines, these vessels represent a total horse-power of 946,811, for the supplying of which there are 567 boilers, with an aggregate of 46,360 square feet of grate surface and 2,062,000 square feet of heating surface. All of the battleships, cruisers and torpedo boats, except the battleship *Iowa,* have water-tube boilers. This is an interesting reversal of the condition of affairs at the time of the Spanish-American War, when, outside of the torpedo boats, there were only four warships then equipped with water-tube boilers. Seventeen of the destroyers burn oil as fuel, and the four latest battleships—*Delaware, North Dakota, Utah* and *Florida*—burn oil in conjunction with coal. The fleet has attached to it a fuel oil tank ship to carry the reserve fuel oil supply for these vessels, serving the corresponding functions of the eight colliers carrying the coal supplies for the other vessels.

The aggregate coal bunker capacity of the fleet is 81,450 tons. Adding to this the coal cargo capacity of the colliers—58,813 tons—the fleet can sail away with a total of 140,263 tons of coal. Propelled simultaneously at their full power, all of the vessels would consume coal at the rate of 20,000 tons a day.

The government has invested in this fleet $123,397,400, to say nothing of the cost of supplies of all kinds and the salaries of the officers and crew.

With its full complement, the fleet would carry 27,344 men and 1,660 officers, a total of 29,004; and it is safe to say the actual figure is in the neighborhood of 25,000 men.

The average speed of the vessels is 21.6 knots. The fastest vessel is the destroyer *Paulding,* which is capable of a speed of 32.8 knots. Placed end to end, touching, the vessels of the fleet would extend a total length of 29,942 feet, or over 5 2/3 miles. If passed in review in single file at an average distance apart of 300 yards, the fleet would form a line extending nearly 23 miles, and an average speed of 10 knots an hour would take about two hours to pass a given point.

The armament of the fleet includes 181 torpedo tubes and 1,590 guns of all kinds. The battleships, armoured cruisers and scouts have either two or four submerged torpedo tubes discharging 21-inch torpedoes, and their battle equipment of four torpedoes for each tube would make a total of 300 torpedoes, each carrying 200 pounds of gun cotton. The torpedo boats each have two or three 18-inch tubes, and in time of war would carry, all told, about 200 torpedoes. A single broadside of torpedoes from the vessels in line would carry a total of 35,000 pounds of gun cotton. Of guns from 6 to 13-inch caliber, there are 496, one round from which would discharge a total weight of 182,800 pounds and require 62,650 pounds of powder. In the projectiles would be carried about 7,000 pounds of high explosives. The range of the largest of these guns is 12 miles, and it is interesting to note that at the recent target practice, from which many of these vessels have just come, remarkable accuracy of fire was shown at ranges of from 15,000 to 16,000 yards. The remainder of the guns in the fleet, ranging in caliber from 1 to 5 inches, discharge projectiles ranging in weight from 1 to 60 pounds.

It is self-evident what such a fleet as this means to the shipbuilding and ordnance manufacturing industries, but there are also less intimately associated industries that played an important part in the equipment of this fleet. We are advised, for example, by the Blake & Knowles Steam Pump Works, 115 Broadway, New York City, that it has installed pumping equipment on sixty-five of these vessels, which is a large percentage, considering that nine of the remainder carry no steam pumps, including the submarines and one sailing vessel, and that eight of the others, principally colliers, were built abroad. The number of pumps this company has installed on the fleet exceeds 1,000, and their cost represents nearly a million and a quarter dollars.

# AN AID
# TO MACHINE SHOP EFFICIENCY

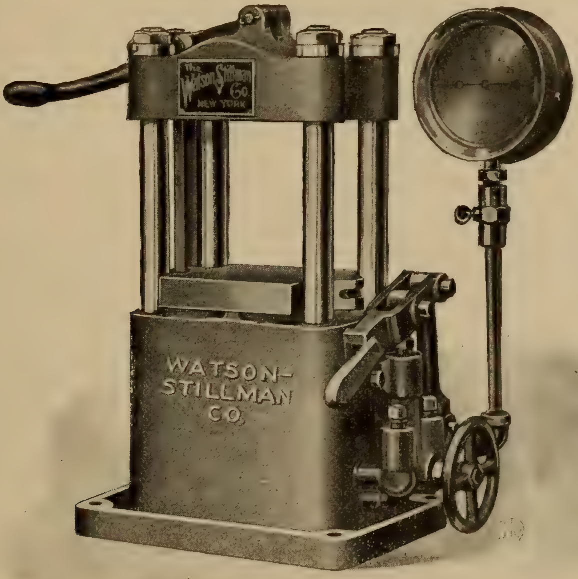
IN every machine shop the occasion often occurs for the press fitting of small parts, or the bringing of a high pressure to bear on small articles, either to bend, straighten or flatten them.

For this service it has been found that a small hydraulic press, of a size convenient to permit its being mounted on a light truck and thus moved with ease and rapidity to any point desired, proves itself to be one of the refinements of modern shop practice which have done so much to quicken production, save time and strength, and assure perfect results.

Many large machine shops have found the small hydraulic press here illustrated, originally designed for laboratory work and for crushing specimens of building material, ideal for such demands as mentioned above, and also for the many odd jobs which constantly crop up in any shop.

In this press, which was designed by the Watson-Stillman Company, of New York, quick movement of the ram is facilitated by the lever and connecting links, shown at the left. The handle at the right on the extension lever socket will operate the pump easily where only light pressures are required, and by applying the extension lever the press will develop a pressure of 30 tons. The platen area is 8 inches square; the platens are 8 inches apart at maximum opening; the ram movement, 4 inches. The base is 12 inches by 16 inches, and the height of the press over all is 27 inches. The main cylinder is a steel forging, machined to fit perfectly into the reservoir, and the pump cylinder is of bronze.

Though, as stated above, this press was originally designed for laboratory work, it is becoming exceedingly popular for use in machine shops, and, being built to withstand severe service, has proved itself extremely valuable when mounted as described.



A PORTABLE HYDRAULIC PRESS.

## A Piece of Rope

A PIECE of rope is a rather simple-looking thing—just some fibres of hemp twisted together, and possessing strength and flexibility—and yet its use in modern engineering has revealed to a remarkable extent the opportunities which it affords for improvement by scientific methods.

The strength of a rope is the sum of the strengths of its several fibres, and if any of these are weak or defective the strength of the whole rope is affected. Scientific tests of hemp fibre have shown very positively just which varieties are best adapted to the manufacture of various kinds of rope for different purposes, and it is interesting to note that a study of hemp fibres under the microscope has enabled the selection of fibre to be made by a method independent of any other source of information.

When a rope is used simply for sustaining a load the strength of the fibres forms the principal element to be considered. In nearly all cases, however, a rope is used in motion, and the great advantage of its flexibility, by which it may be passed around pulleys and sheaves, gives it a wide range of usefulness. It is in this very matter of bending around pulleys that an entirely different feature in the quality of rope comes up for consideration. Anyone who has had occasion to use a rope for hoisting by use of the ordinary block and tackle knows that a very marked resistance is opposed to the bending of the rope over the sheaves. The sharper the bend, the greater the resistance, and hence the loss of power from this source is very materially reduced by increasing the diameter of the sheave.

The resistance to bending is largely due to the internal friction in a rope, caused by the sliding of the fibres upon each other. The outer portion of the bend is under tension and the inner part under compression, and the continual shortening and lengthening of the various portions of a rope as it passes over a pulley necessarily means much sliding and rubbing of the fibres and strands, and when the bends are short and the load heavy both resistance and wear become important matters.

The standard remedy for friction is lubrication, and for the lubrication of a rope a solid lubricant is essential. Plumbago has been found especially suitable for reducing the internal friction in a rope, but in order to be effective it must be properly applied. Very little lubricant can be introduced into the interior of a rope after it is made, and the proper method is to have the graphite laid into the fibres as the rope is manufactured.

Experience has shown that, with a rope thus internally lubricated, the wear is greatly reduced, while a rope which has not been laid with a lubricant is continually grinding itself to pieces while the exterior is apparently sound. In some instances a rope, upon cutting apart, will be found to contain a cover of loose fibre and dust, caused by the attention of friction.

This internal wear is especially to be guarded against in rope used for power transmission, since the bending and straightening occur continuously. Every time the length of the rope passes over the pulley every part of it has been put through a course frictional wear which consumes power and produces injury.

It is evident that rope made from the best grade of selected long manila fibre, carefully laid with a lubricant of plumbago, will cost more than a rope of similar appearance made from material of a lower grade with little or no lubricant. The question of cost, however, becomes insignificant when taken into consideration with the increased value of the higher-grade product. The loss due to the extra power consumed in a cheap transmission rope is a continuous loss, entirely apart from the shorter life of the inferior article, and the economy far overbalances the higher price.

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**If you are thinking of buying rope, carefully read the following guarantee**

We guarantee that more work can be done with "Stevedore" Rope in proportion to its cost, than with any other rope in the market, without any exception whatever, and will gladly refund the difference in price if it is not all we claim.

You cannot lose one cent by making a trial of this rope, and are sure to reduce your expense account. Before you forget it, purchase a length of this rope to compare with that you are now using.

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### Efficiency

THERE has been so much talk of late about efficiency in the work of men that it seems pertinent to say something about the importance of efficiency in machinery. To many men the idea of efficiency is rather indefinite, meaning something rather above the average, but not capable of any very precise definition. As a matter of fact, efficiency is definite or indeterminate just so far as the data upon which it is computed are definite or otherwise. Efficiency is not a positive quantity, but rather a percentage of useful effect which is obtained by man or machine in comparison with what may be termed the maximum effect attainable. In some cases this is very readily determined; in others it can be only approximate. Thus, we may take the simple case of the lifting of a weight, and we know that a load of 100 pounds raised through a height of 10 feet corresponds to precisely 1,000 foot-pounds, neither more nor less. If the apparatus by which it is raised consumes energy equal to 2,000 foot-pounds, it is evident that only one-half of the energy put in is returned in useful work, and the efficiency of the arrangement is clearly only 50%.

If we have 100 pounds suspended at each end of a rope passing over a single stationary pulley, it is evident that the two weights will just balance each other, and that if we wish to cause one of them to rise we must add some weight to the other side. The amount of weight which must be added depends upon the resistances opposed by the friction of the bearings of the pulley and by the amount required to overcome the stiffness of the rope. The efficiency of such an arrangement depends, therefore, upon the extent to which we can reduce these opposing resistances. When we have a number of turns of rope passing around several sheave pulleys, both fixed and movable, as in the ordinary rope tackle, there will be a corresponding increase in the obstructing resistance, and hence a reduction in the efficiency.

With some machines it is not so easy to determine just what the efficiency really is, because we have no way of knowing just what the maximum performance should be—that is, just what the 100 per cent. efficiency is—and so our principal upon which the rate is computed is not definitely known. Thus it is a matter of opinion or experience as to the greatest amount of good work which can be turned out by a lathe or planing machine, and what may be considered a high performance to-day may be greatly exceeded by some improvement introduced to-morrow.

An efficiency computed upon any such assumption is, therefore, only temporary, and liable to revision at any time. In machines of a certain type it has sometimes been found desirable to introduce such a frictional resistance as will serve to check or resist movement at certain periods. When such resistance is acting at all times it necessarily tends to reduce the efficiency of the machine during its operation. This combination existed with the earlier types of chain hoists, in which the internal frictional resistance was great enough to hold the load from descending, and hence was more than half as much as the effort put into the hoisting pull, being in effect all the time. Blocks of this kind could not have a greater efficiency than 50 per cent. The late Thomas A. Weston, in his valuable invention of the Triplex block, arranged the mechanism in such a manner that the sustaining friction acted only to prevent the descent of the load and did not have to be overcome during the operation of hoisting, and thus at one stroke the efficiency was raised from 40 to 80 per cent.

The secret of efficiency thus appears in the simple plan of cutting out useless resistances and giving the useful work opportunity to effect its result.

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### Scientific Pulleys

USERS of belting for the transmission of power have long since recognized the desirability of employing pulleys made in halves and bolted together, rather than to use the old-fashioned kind, cast whole and bored out to fit the especial place of use. At first sight, the solid pulley seems to possess the advantages of simplicity and strength, but a comparatively brief experience in a modern manufacturing establishment will reveal the fact that a controlling element, that of convenience, is lacking in the solid pulley.

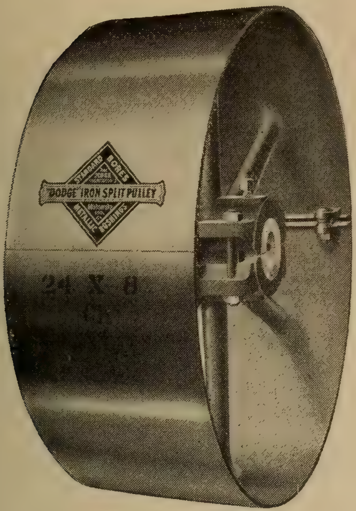
In the first place, there are so many variable elements in the requirements for pulleys that it is physically impossible for a fairly complete line to be kept in stock. The diameter of a pulley must be that to give the required speed; the face must correspond to the width of the belt, itself a function of the amount of power to be transmitted; the bore of the hub must correspond precisely with the diameter of the shaft upon which it is to be placed, and hence the hub upon the casting must be made to suit, while the face must be turned either straight or crowning, according as the belt is to be shifted or not. Since any one of these elements may be varied, the mathematical laws of permutation might well be invoked to determine how many different pulleys would have to be kept in stock to meet the ordinary calls of the trade, and the result would work out somewhat like the old example in arithmetic of the value of the nails in the horse's feet.

As a matter of fact, the idea of keeping finished solid pulleys in stock has not been attempted, and such pulleys are nearly always finished to order for the particular job for which they are wanted. This necessarily involves the loss of considerable time, while the possibility of error is serious and the ability to make subsequent modifications in plans impeded.

Apart from the inconvenience involved in making pulleys to order, the solid pulley has the great disadvantage of requiring to be put on the end of the shaft and slipped along to the position where it is to remain. This means that the coupling has to be disconnected and the intervening pulleys removed and replaced and the coupling reconnected. Doubtless this frequent derangement has much to do with the defective alignment of shafting, which causes excessive frictional losses.

Two modifications have enabled all the above difficulties, inherent in the solid pulley, to be entirely removed. By making the pulley in two parts it may be placed upon the shaft in precisely the position desired, without requiring anything whatever to be done to anything else. The shaft might be absolutely continuous and incapable of disconnection, and no impediment would be placed in the way of the split pulley. Alignment is not meddled with, other pulleys remain untouched, and the only time required is expended upon the new pulley itself. By providing the split pulley with a hole of standard maximum bore the system of interchangeable bushings may be used, and thus one of the most exacting of the variables removed, so that the carrying of a reasonable line of pulleys of various diameters and faces in stock becomes practicable, and the fit upon the shaft is made by selecting the proper bushing.

The same advantage which the split pulley and interchangeable bushing provide to the dealer in maintaining a stock comes to the aid of the manufacturer with his own stock of pulleys upon the line shafting of his works. The item of depreciation becomes a very important one with the solid pulley, because each pulley can be used only in its original place, and rearrangements and transpositions become impracticable. The second-hand solid pulley is usually worth little more than scrap iron; the split pulley has a useful life of indefinite length.



# Why Leading Manufacturers Have Adopted The

DODGE

# "Standard" Split Iron Pulley

CONCERNS like Buick Motor Co., Postum Cereal Co., Ltd., Corn Products Refining Co., E. I. Du Pont de Nemours Powder Co., and hundreds of others have adopted Dodge "Standard" Split Iron Pulleys as their pulley standard after thorough try-outs of all types of metal pulleys. ◆ In those factories they have found that "Standard" Splits are the acme of pulley economy. They offer advantages—important features—that can be secured in no other kind of metal pulleys. ◆ Common solid iron pulleys must be made to order, requiring several days' time. Then they are good only for the one size of shaft for which they were made. ◆ The Dodge "Standard" Split Iron Pulley can be secured in any regular size from the stock carried by any of our ten branch houses and more than two hundred selling agents—at once—when you need it. It has interchangeable bushings to fit it to all sizes of shafting so that it may be quickly moved—being split—from one shaft to another throughout the factory. ◆ This Dodge Pulley is wholly different from the ordinary bushed, metal, "stock" pulley. It is made of cast iron—round, true, balanced, and cannot but stay that way. Non-flexible, there is no bending out of shape, and it has no riveted joints to work loose or shear. And it is fastened to the shaft by compression, reinforced by two set-screws—an exclusive "Standard" Split feature. ◆ Dodge "Standard" Split Iron Pulleys reduce the depreciation charge, for they have a permanent value. They neither wear out, rack out nor become less efficient with time. These are the pulleys that are needed in your factory. The coupon or a letter will bring you more complete descriptions of Dodge "Standard" Split Iron Pulleys—and prices which will prove that they cost no more than types of minor value.

### This Dodge Calculator is a Wonderful Saver of Time and Figures for Factory Men

You will find it invaluable, once you have used the Dodge Calculator. ◆ It figures your shafting, belting and pulley problems quickly and easily—simply set the slide and read the result. You can find the horse power and speed of shafting, the width and travel of belts, what size pulley and friction clutch to use, practically in an instant. No delay—no long process of figuring—no complicated rules to remember. ◆ Factory managers, superintendents, purchasing agents, master mechanics and engineers everywhere have bought this calculator and found it worth many times its price. Our present supply will not last long. Send us the coupon and 25 cents at once and we will send the calculator in genuine leather case, by return mail. Money back if you're not fully satisfied.

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Dodge Mfg. Co.,
Sta. E-11, Mishawaka, Ind.

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**Station E-11, Mishawaka, Indiana**

Everything for the Mechanical Transmission of Power

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### The Reach of the Stone Channeler

LOOKING out from, say, a fifteenth or a twentieth-story window of one of the latest office buildings of lower New York City, one realizes the vast difference between the old and the new constructions, and the wonderful jump which has been made in the building habit in the last score of years.

Large masses of the old buildings still survive, rising quite uniformly to a height of five or six stories, and from the irregular, approximate level of their roofs the new buildings tower a dozen or a score of stories higher. In comparing the new structures with the old, it will appear that there has been not only a complete transformation of building methods, but also a change quite as complete in the materials of construction, the former being largely the result of the latter.

The modern building could never have been even planned until the steel and the stone and the concrete came in sight and became readily and cheaply procurable. The dominant building material of the latest completed century was brick, with wood for the floor timbers, and later iron beams; now bricks are the incidental and the supplemental rather than the most essential element, and stone instead of brick strikes the eye in all the newer city erections.

While there is much wondering exclamation and much glorification over the skyscrapers and the other pretentious and imposing structures of recent years, nothing but ultimate pecuniary profit has dictated their erection. Modern buildings are a great bargain at the beginning, and they are built, first of all, because they are really cheap. It has been said that, where the most pretentious office building of half a century ago cost two dollars per cubic foot of available space, enclosed, the corresponding cost of the later erections is not more than one-quarter of that amount.

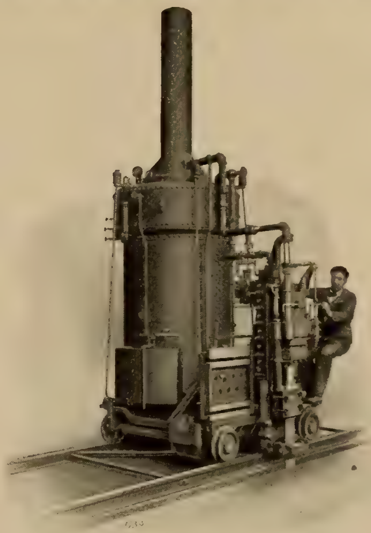
One of the most persistent and effective cheapeners of stone production for the upbuilding of our modern cities all over the land is the stone channeler. Not many who walk city streets or who ply their various schemes and activities in the big new buildings have ever seen a stone channeler at work, yet they all must owe a lifelong indebtedness to it for helping to provide the best business accommodations the world has ever known.

The largest single complete structure in the world built entirely of marble, and its exterior all of marble from a single quarry—the Metropolitan Life building, in New York, with its already world-famous tower—owes its existence, among other agencies, to the stone channeler; and it may be said that, without the channeler, while its erection would not have been physically impossible, financially it would have been.

The stone channeler, to a considerable extent, dictates or determines the kind of stone that we shall use for our buildings. While we may fret and worry about the prospective exhaustion of our coal and our iron, we cannot exhaust the stone which may be used for building purposes. Some, however, as the granites, the channeler cannot cut, while others it walks into quite rapidly; and the latter, therefore, is the stone which is becoming all the fashion for general building purposes.

It is a curious thing that, in contrast to the Metropolitan Life building, referred to above, as the product of the channeler, there is rising also in New York one of the most imposing structures designed and erected by man, the Cathedral of St. John the Divine, in whose erection the channeler cannot claim a prominent part. The materials of which, mostly, it is constructed have not been gotten out by the channeler. We may reasonably expect this building to outlive all the others within sight of it; but, according to our modern habits of change, they will, doubtless, all last long enough.

# STONE CHANNELERS



## THE VITAL QUESTION

With quarrymen and contractors using stone channelers the vital question is the cost of channel per square foot.

This is not simply a question of power. It involves the items of upkeep and labor as well.

Ingersoll-Rand Channelers—"Monitor" heavy duty, "Ram" marble and "Broncho" bar—embody every element of economy, whether steam or air driven.

And there is the "Electric Air" Channeler, electric driven, for conditions affording electric current.

Their power requirements are reasonably low for their large capacity. Their up-keep charges are consistent with their rugged, wear-proof construction.

Their capacity is so large that the labor cost per unit cut is exceptionally small.

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### A Matter of Productivity

MODERN methods of works management will fail very largely to accomplish their desired end if they are limited only to the increase in efficient performance of the men; the acceleration must also be extended to the tools. When "all-round" work is done by "all-round" machinists there is probably no better tool than the standard engine lathe; but machining operations are becoming specialized, and designers of articles to be manufactured are learning to standardize the various parts to an extent which enables much of the work upon them also to be standardized.

Thus, the entire development of the automobile industry, a growth which has taken place mainly within the past ten years, requires the machining of pistons, cylinders, small fly-wheels, and the like; while the similar progress of the motor boat, and indeed of the combustion engine generally, extends this class of work almost indefinitely. In railway shops there appears a quantity of machining work which is capable of standardization and systematic production, and in the arsenal the manufacture of projectiles alone gives wide scope for a suitably designed turret lathe.

A turret lathe for such work must be something far more than an adapted engine lathe with a turret placed on the shears. A heavy turret lathe may doubtless be constructed in this fashion, but the essential requirement of large productivity of accurate work is not to be met in this manner. Neither is it desirable to assume that lighter machines of earlier models form proper guides for the design of the heavy turret lathe of large output. The problem of the design of such a machine should be attacked in the same manner as any other scientific engineering question—upon its own merits and in accordance with its own conditions.

Increased output means increased speeds and heavier stresses, together with such improved facilities for handling the work that no waste movements are made.

These requirements demand, above all things, a degree of rigidity which shall permit the severest service without appreciable yield or spring; work cannot be turned out to maximum advantage if there exists any timidity about springing. Such rigidity may be provided in individual parts by the proper distribution of ample material, but in a machine tool there must also be considered the nature and extent of the supports provided for the several moving and adjustable details. Ample wearing surfaces, sufficient base area, reduction in overhang, both of tools and supports—these elements all enter into the attainment of that rigidity and stiffness which are essential for the production of good work.

It is evident that such construction includes parts much heavier than ordinarily employed, and the condition of easy manipulation of such parts calls for the aid of power in their movement. Since the same machine should be available for both bar and chucking work, a wide working range is essential, permitting large diameters to be turned or pins of moderate size to be finished.

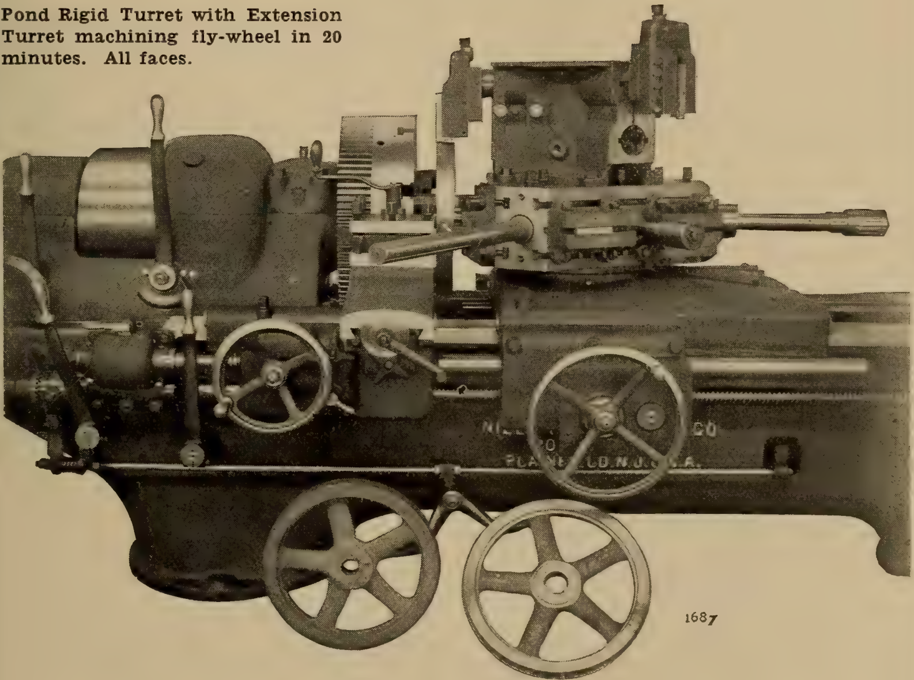
A wide range of capacity means a corresponding range of speeds, and provision should be made for the ready change of speed, since such changes have often to be made several times upon a single piece of work. Such changes are best made by the use of change gearing, controlled by a system of levers, the machine being driven by a single pulley, or by an electric motor.

With a machine constructed upon such lines the increase in output over that of a standard engine lathe is remarkable. The gain naturally depends somewhat upon the nature of the work, but it has been found to run from 50 to 150 per cent., while the work itself is more fully under control than is practicable with machine tools of older types.

A BROAD STATEMENT

An Increase in Output
From 50 to 150 per Cent.
Backed up by the

Pond Rigid Turret with Extension Turret machining fly-wheel in 20 minutes. All faces.



Pond Rigid Turret Lathe

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### The Cost of Idleness

According to the old-fashioned methods of cost-keeping, the time of various kinds of labour was carefully kept on a repair job, and the material weighed, measured and charged up, and when to these there was added a suitable amount to cover the expense charges, the correct cost was assumed to have been determined. While this method may be all right for finding the cost of newly-produced articles, it is open to distinct criticism when applied to the repairing of machines which have been disabled in the course of productive work and which are being repaired to be returned to service.

Modern shop systems, and modern business methods in general, allot to each machine a definite earning capacity, usually expressed in the form of a daily or hourly machine rate, as it is termed, and such machines, representing the investment of large sums of money, must be kept at work all the time, in order to justify the expenditure involved in their purchase. If a machine, for any reason, is allowed to stand idle, the charge against it mounts up, and it becomes a burden, instead of being a useful, productive investment. Since this waste is dependent upon time, it is evident that the loss due to the idleness of a machine while it is undergoing repairs is greater or less according to the time expended in restoring it to a productive condition. There should, therefore, be added to the ordinary charges for labour, material and general expense a further charge for the time the machine is out of service. The only way in which this loss may be kept down is by making the repairs as quickly as possible, so that the burden of idleness may be removed and the renewed period of earning service begun. When a job is kept in the repair shop a day longer than is actually necessary the loss of money due to loss of service must be considered preventable.

One of the best illustrations of the above facts appears in the case of the locomotive repair shop. On a well-managed railroad the rolling stock is kept in active paying service as much as possible, and it is fully realized that locomotives are built to haul trains and not to lie out of service, either in roundhouse or repair shop. Every day that a locomotive is idle it represents a loss equal to what it would be earning if it were out on the road. A few days of such idleness will amount to far more than the actual shop cost of putting the engine in order, and if the repair work is unduly prolonged the charge for idleness of the locomotive will far exceed the value of the work done in the shop. Apart from the incentive which an appreciation of these facts offers to push repair work through with all practicable speed, the cost of idleness of a productive machine becomes a powerful argument for the use of materials and methods of construction in the first place which shall avoid the necessity for repairs. Not only should an engine be designed for power convenience and efficiency on the road; it should be so built that it will stay on the road, and not be making frequent visits to the repair shop, there to lie in costly idleness while money is being spent to get it out on the road again.

The heavy and sudden stresses which come upon locomotive frames, and the heavy losses which follow breakages of frames under such conditions, make the use of vanadium steel especially desirable for such fundamental parts. When good ferro-vanadium is added to the steel, the tensile strength of the forging may be kept at a maximum, while at the same time the toughness and resistance to shock are greatly increased. It is by such methods that the cost of idleness may not only be reduced, but in many instances wholly avoided, by rendering repairs unnecessary, and thus keeping the engine in service continuously.

# VANADIUM

## Efficiency

Vanadium Steel keeps locomotives on the road where they ought to be, and out of the shop, where they ought not to be.

Vanadium Cast Steel frames are as strong as carbon steel forgings, their average tensile strength is 80,975 pounds and the average elastic limit 45,024 pounds. These averages were obtained on more than a thousand frames now in satisfactory operation on twenty-two of the best railroads in the country.

Wherever iron or steel fails by wear, crystallization and breakage, Vanadium Steel will succeed because of its strength, toughness, durability and anti-fatigue qualities. Greater efficiency, a higher factor of safety and less cost for repairs always result from the use of Vanadium Steel. Booklets free.

**American Vanadium Company**

**Miners of Vanadium Ores**
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You cannot make good Vanadium Steel without good Ferro Vanadium. A full knowledge of the analysis of Ferro Vanadium is essential to guard against the introduction of impurities that will damage your steel more than the Vanadium will improve it. Ferro Vanadium containing carbon is almost worthless.

"Amervan" Ferro Vanadium is the result of years of careful and scientific experiments. Every shipment is analyzed and its composition is known exactly. There is no guess work and you run no risk of spoiling an entire heat of metal.

"Amervan" Ferro Vanadium is made in the largest factory in the world for the production of Vanadium Alloys, a factory that makes nothing else but Vanadium Alloys and always makes them right.

### Transportation Problems

ATTENTION has already been drawn, in this magazine, to the defective element in the conveyance of merchandise to various parts of a great city from its railway terminals, and the points which have thus been made have attracted a certain amount of attention. The subject is such a wide one, however, that it will bear further discussion, and there are certain points about it which may be examined more in detail.

In the first place, the only terminal in which the shipper is really interested is his own platform. When a manufacturing concern accepts the inducements held out by a minor centre to establish itself within its limits, one of the inducements invariably presented is direct connection with a railway. Siding facilities are offered, and opportunity is given to receive material by rail and deliver the completed product directly to the railroad without delay or obstruction. When we come to the great cities, however, a different state of affairs appears. The opportunities for obtaining individual sidings are limited, and by far the greater part of the merchandise has to be hauled to and from freight stations, often situated at points remote from the manufacturing centres, and usually in control of individuals who have no interest in furthering the efficient conduct of business.

Under such circumstances the manufacturer in metropolitan districts must depend upon his own initiative to bridge the gap between the railroad and the shop. Formerly he had recourse to the horse-drawn vehicle—slow, inefficient and costly. To-day he is looking to the motor truck to solve the problem which has been thrust upon him.

Anyone who has observed the long lines of horse-drawn wagons filling the approaches to the terminals of railways and the piers of steamship lines must realize that here lies the defective link in the chain of transportation between shipper and user, and that the opportunity for reform is greater here than at any other point along the line. Any complaints of shippers at the cost of railway transport become trivial in comparison with the charges which they have willingly paid and the delays to which they have submitted in matters almost wholly within their own control.

The engineer has come to the rescue, however, and by the perfection of the motor truck has provided the remedy. The merchandise practically abandoned by the railway at a limited number of points within the limits of a great city is no longer obliged to lie until the feeble efforts of a few overworked animals are available for its removal. With the advent of the motor truck the ability to remove and deliver merchandise from station to factory is limited only by the handling facilities, and these latter may well be provided, in sheer self-defense, at the railway freight station.

The design and construction of the motor truck may vary according to the general experience of the builder and the demands of the customer. In general, the gasoline-driven truck, equipped with long-stroke engine and built for heavy service, will be found fully equal to the demands which may be made upon it.

Builders have clearly found out that the conditions governing motor truck service are very different from those which obtain in the case of pleasure vehicles. Power is certainly required, and with ample power in the engine there should be associated a complete control, a powerful emergency brake, and a very low gear, the latter being especially desirable if the machine demands a strong effort to release either itself or some other vehicle from an obstruction of any kind. The possession of ample power, complete control and full capacity for carrying the burden unite to make the motor truck the immediate solution of the terminal transport problem.

The Motor Truck is Your Opportunity

There is a "flood tide in the affairs of men"—there always comes a time in the conduct of every business when a decision for or against new methods determine whether it shall be a leader in its line or the reverse. The Commercial Vehicle is one of the modern improvements—one of the new methods that must solve the cartage problem. We cannot shift the responsibility.

White Trucks Serve Securing and keeping trade is growing more and more a matter of service, whether in retail or wholesale lines. In this realm of service nothing is more potent in securing results than the motor truck. The truck is an untiring, reliable steel-and-iron servant of all departments—a machine to take the place of animal flesh and blood.

White Trucks Save Through the service they perform, such as increasing the number of trips per day, or the breadth of territory covered, or by long, continuous, daily service, motor trucks, either directly or indirectly, are big economical factors in every business. Each truck or delivery wagon replaces from four to eight horses, in accordance with the capacity of the truck.

White Trucks Superbly Built

White trucks secure results because they are superbly built—because the engine was designed for a truck and has the simplicity which means good mechanical principles, accessibility of every part, and that it is easily driven. The materials are the best that modern science has evolved, including the highest types of steel alloys and the heat-treatment of them. The White factory not only has the mechanical equipment and skilled workmen, but fifty years of manufacturing experience and the financial responsibility.

Let us submit a solution of your delivery problem—send our latest truck catalogue—list of owners in your territory and the testimonials of some of the largest users in the world.

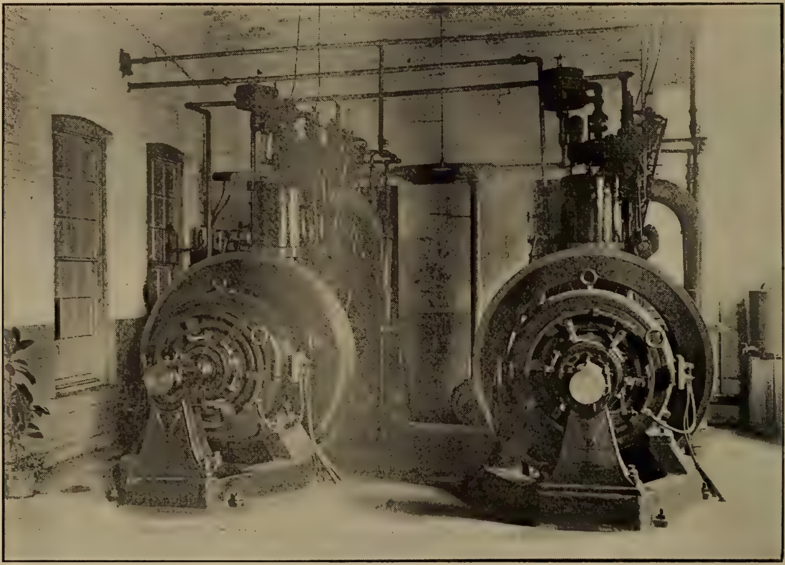
**The White Company**

832 EAST 79th STREET, CLEVELAND

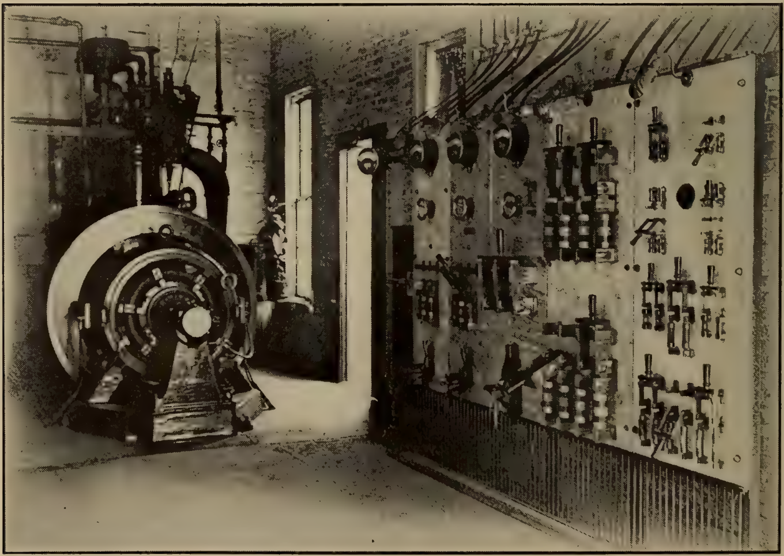
# THE AUTOMATIC SCAVENGER

## A FEATURE OF GAS ENGINE DESIGN

IT is now generally conceded that the internal-combustion engine offers great advantages over the steam engine for the conversion of the heat energy in fuel into active power for useful work. The gas engine has already shown a far higher efficiency than is possible with the steam engine, and the combination of gas producer and gas engine is undoubtedly more effective than the steam boiler and steam engine.



GAS ENGINES INSTALLATION, OHIO CULTIVATOR COMPANY.



This is conceded from a theoretical point of view, but it is not every gas engine which enables these advantages to be practically realized.

The Jacobson gas engine, which is illustrated herewith from photographs taken from an actual installation at the works of the Ohio Cultivator Company, Bellevue, Ohio, is a machine which unites with the theoretical possibilities of the gas engine the practical results of careful study and long experience.

Among the special features of the Jacobson gas engine, one of the most important is the automatic scavenging arrangement, by means of which a draught of pure air is swept through the combustion chamber, clearing it of all burnt gases before the combustible charge is admitted.

The air and gas are admitted to the valve chamber, in which are arranged two valves on one stem, the lower, or solid, valve being the air valve in one piece with the stem, and the upper being the gas valve, which slides on the stem of the air valve and is held up to its seat by means of a coiled spring in compression between the two valves. The cams operating the valves are so arranged that the air inlet valve is opened just before the exhaust valve is closed, causing a sweep of cold pure air to clean out the combustion chamber. Then the exhaust valve closes and the combustible mixture is admitted to the chamber.

These valves are all so arranged that both valves and seats may be removed for inspection, cleaning and grinding without breaking either cylinder or pipe joints or disconnecting any other parts.

The same idea of accessibility is extended to the other portions of the engine. Thus, by removing one side of the crank case the entire mechanical portions of the engine are thrown open, giving complete access to cranks, connecting-rods and bearings, and permitting the working parts to be removed for examination or repair without making any trouble or delay.

The two engines shown in the illustrations have been in continuous operation for six years, working

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daily for all of the time, and day and night for part of the time. After five years of such work the only repairs needed were a few sparking points and a set of exhaust valves.

The Jacobson gas engine is built in sizes from 20 horse-power to 3,000 horse-power, for use with either producer or natural gas, and represents a most practical and efficient type of internal-combustion motor. Any inquiries concerning the engine should be addressed to the Jacobson Engineering Company, Saratoga Springs, N. Y.

### The Science of Industrial Indemnity

Nearly every year perils inevitable to an age of industry kill their thousands and maim their tens of thousands. In the whole body of American industry we have often wasted, not only foolishly, but cruelly, and nowhere more cruelly than in the matter of provision for the wreckage of industry, the killed and wounded in our industrial warfare.

We have recognized dimly that either society or the industry in question owes to this wreckage some form of support for crippled, impotent years, or for a new generation of unprotected survivors.

But we are struggling along on a system of compensation for industrial accidents which is a relic of the old hand-labour days, and which has worked out into a tangle of law, highly expensive, incredibly complicated, and decidedly unjust. All the so-called progressive nations entered the era of specialized labour and machine production with legal principles similar to ours; all but the United States have either amended them or changed them utterly to fit the necessities of the new age.—From Will Irwin's "The Awakening of the American Business Man," in the May *Century*.

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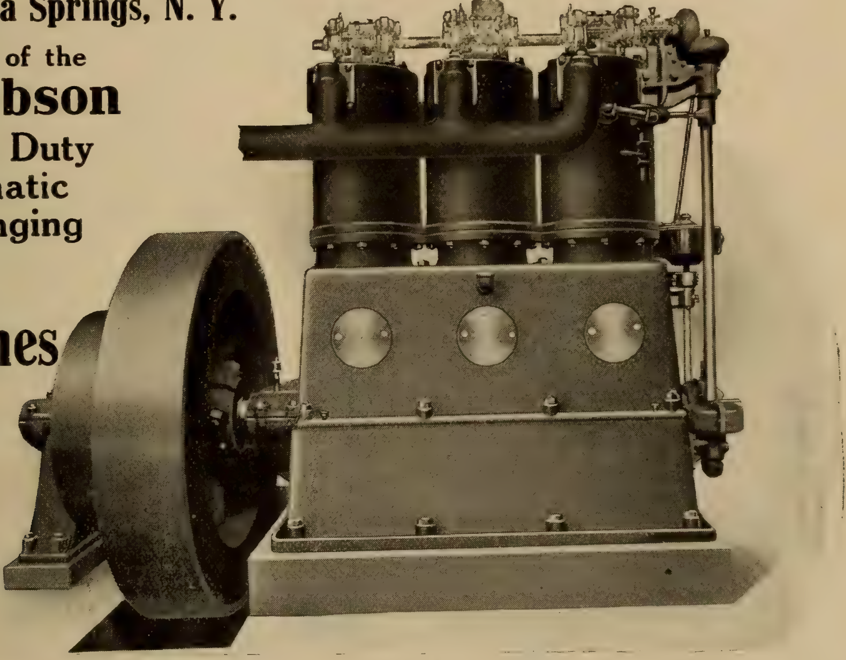

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## GAS ENGINES

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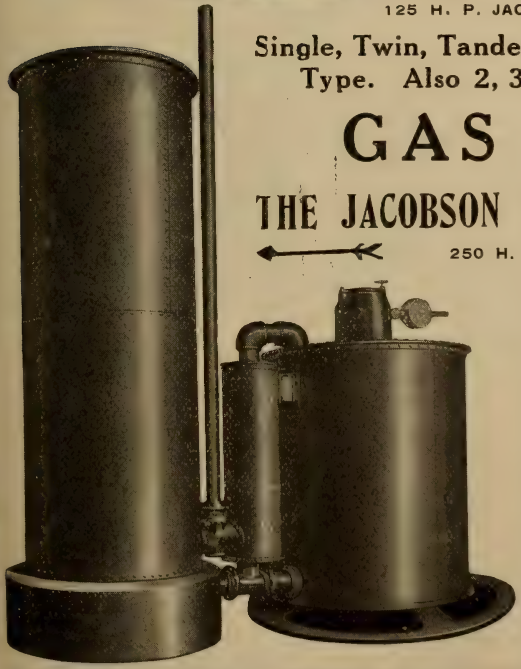

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Contractors for complete power plants operating on Natural Gas, Producer Gas, and Crude or Fuel Oil.

**SARATOGA SPRINGS, N. Y.**

**Sanitary Cleaning**

THE ordinary factory or city office is a dusty place, and we have all become so used to this that we hardly appreciate the comfort and satisfaction which may be derived from an office which has been properly cleaned.

The charwoman or porters are assumed to clean every office each night; but, as a matter of fact, the cleaning which is given is very superficial, and, as a rule, consists in whisking the dust off the desk and allowing it to settle on the floor or tops of bookcases, cabinets, and other articles of furniture.

Until the introduction of the portable vacuum cleaner there was really very little else that could be done.

The modern vacuum cleaner is the result of a world-wide demand for a complete and sanitary method by which the dust and dirt which accumulate in houses, homes, offices, libraries, and, in fact, wherever people congregate, can be removed.

The value of this method of cleaning for home and general purposes has been demonstrated, and its use in office buildings, so far as cleaning corridors and here and there carpets or floors, is being appreciated; but until the development of the portable vacuum cleaner, Santo type, it was impossible to obtain the full advantages of this method of cleaning.

Real cleanliness cannot be obtained by merely removing visible dirt, and the dusting of an office simply means that the visible dust on desks and the few articles which attract the eye have been brushed off and have floated to the floor or distributed themselves throughout the room. Each breath of air which blows through the windows or the opening of a door and the draught created thereby, or walking across the floor, raises a cloud of dust, which is blown about the room and breathed in with the air by the occupant, or finally settles down again until disturbed and started floating once more.

The only way to really clean and remove the dangers incident to the clouds of dust which are brought in from the street and which blow in through the windows, is to literally pick it up and remove it bodily, as is done with the vacuum cleaning machine. This fact is being realized, and to-day there are many offices in buildings where they have stationary plants where the Santo is kept in the office always ready for use.

Owing to its balanced construction and method of suspending the moving parts on springs, the machine operates without vibration or noise, and, consequently, can be used in and around the office during the working hours. Further, due to the fact that the machine absolutely removes the dirt and dust, when once an office is cleaned in this way, subsequent cleanings are greatly simplified, because only the small accumulation of each day has to be removed.

REMOVING, NOT ALONE MOVING THE DIRT

For library use, both public and private, the Santo method of cleaning is an ideal one, as it permits all the books, shelves, racks, floors and furniture being cleaned without the removal of the books, and, consequently, wear and tear; and, further, the cleaning can go on throughout the day without disturbing readers.

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A REVOLUTION

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or
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The picture given herewith shows the Santo cleaner in use, and affords an idea of its relatively small size and convenience with which it may be operated.

The Santo uses a ⅛ horse-power motor, and, consequently, can be attached to any lighting fixture, either in office or home, without danger of invalidating insurance. It produces a vacuum of from 7 to 8 inches, and, consequently, has sufficient power for thorough cleaning.

The volume of air handled is ample to convey the dust from the renovator to the dust receptacle in the machine. Owing to its circular form and small size and light weight, the machine can be readily handled and stowed away when not in use.

The machine is manufactured and sold by the Keller Manufacturing Company, Philadelphia, Pa., and also through their branches and general agents located in the principal cities throughout the United States, England and the Continent.

### Great Expansion in the Use of Expansion Bolts

An exceedingly large demand for their "Sebco" expansion bolts is reported by the Star Expansion Bolt Company, of New York. Elaborate tests of this well-known expansion bolt have shown that their resistance of strain is remarkable. A recent test showed that a ½-inch diameter bolt, 3½ inches long, withstood a weight of 8,200 pounds before stripping the threads of the lag screw. Another test developed the fact that the shield would strip the threads of of the lag screw before pulling out. These bolts are of the same diameter at both ends, thus affording an even and firm grip when expanded, and the ribs are so sharp and deep that, while the shield is being expanded, the building material fills in and around the shield, embedding the shield in the material. Other special features are: absolutely clean threads, which permit free running of the lag screw, tight fit of the shield into the hole, allowing no play, and abso-

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We also make a full line of Society Emblem mountings. Advise what emblem is desired and we will advise you price.
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lute prevention from turning in the hole, due to the deep grooves and the two lugs, which bite into the building material when the expansion is made.

### Steam Pumps

A highly polished oak plank, bearing the well-known acorn trademark embossed thereon, forms the cover of a handsome illustrated catalogue issued by the A. S. Cameron Steam Pump Works, of New York. This publication, as might be expected, has an individual character, and, like all other products of the Cameron Company, fulfills the promise of their slogan, "Character: The Grandest Thing," a slogan which, by the way, these pumps have lived up to for over fifty years. This book consists of over 150 pages of text, with many fine illustrations, and contains a vast amount of information of service to pump users. Copies can be obtained by addressing them.

### A Typewriter for Tabulating Work, Writing a Line of 487 Characters

No better proof of correct mechanical principles in typewriter construction could be given than is exemplified in the Monarch, with a 42½-inch carriage and with a writing line of 487 characters.

A typewriter writing nearly 500 characters to the line must of necessity be out of the ordinary. It is most extraordinary, and the Monarch Company is proud of the claim that it cannot be accomplished in any other make of typewriter and still retain the extremely light action and velvety touch that is making the Monarch famous. The frictionless roller bearing segment (capital) shift and the frictionless roller bearing non-shifting (rigid) carriage makes possible this wonderful model.

This machine was manufactured by the Monarch Typewriter Company expressly for and was recently installed in the office of the Chicago Telephone Company, Chicago, Ill., for special work in tabulating.

The typist operating this extremely wide carriage typewriter experiences no "three o'clock fatigue," a feature that the many friends of the Monarch find both in the ordinary commercial model and in the wide carriage field all over the world.

### Lap Welded Steel Pipe

Due to their method of welding and annealing, the lap welded steel pipe manufactured by the American Spiral Pipe Works, Chicago, Ill., has remarkable strength, and is especially suited for gas, vacuum and high-pressure hydraulic work, where absolute tightness is essential. This pipe is made from low-carbon, open-hearth steel, is thoroughly annealed after completion, and is furnished in any required length with forged steel flanges attached. They also furnish necessary fittings for complete installations.

### Purchase by U. S. Government of Gas Engines for River Improvement Work

For use in operating one of the dams in the river improvement work near Wheeling, the United States Government recently received from the Foos Gas Engine Company, of Springfield, Ohio, two Foos gas engines, which are part of the order from that company.

These engines are designed along the lines of their heavy-duty, vertical, multiple-cylinder type, consisting of three cylinders, each of 100 horse-power capacity, and will be installed at Dam No. 8.

### Illinois Appoints New Professor of Mechanical Engineering

Professor Charles Russ Richards, Dean of the College of Engineering of the University of Nebraska, has been appointed professor of mechanical engineering in charge of the department at the University of Illinois, effective September 1, 1911.

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# FINANCIAL NOTES OF THE INDUSTRIAL WORLD

### New York's Newest Banking Centre

Those who predicted some years ago that Thirty-fourth street would be one of the busiest commercial centres in the city of New York must feel a sense of gratification in seeing their prognostications come true.

This section of the city, known as "The Heart of New York," has demonstrated conclusively its importance as a business centre, and it now holds one of the foremost places in the commercial world.

Old residence buildings are being demolished to make room for the new and modern office buildings which are needed to house the various business enterprises, and its prominence is still more marked by the number of large manufacturing industries which have recently located in this vicinity. The new Greeley Square Hotel, which is now under construction, is another illustration of the growth of this neighborhood.

Added to all this are the banking facilities which are offered to the permanent and traveling public. The Chelsea Exchange Bank, located about 100 feet west of the Thirty-fourth street entrance of the new Pennsylvania Railroad terminal, occupies a very enviable position in this section. It owns a frontage of 45 feet of very valuable property right on Thirty-fourth street, and those who are looking for a strong, conservative bank should patronize this institution. Then there is the West Side Bank, located on the northwest corner of Thirty-fourth street and Eighth avenue, and a branch of the Corn Exchange Bank, with banking offices right in the Pennsylvania terminal building, to say nothing of the numerous other banks which are just east of Broadway.

Present indications are that this section will enjoy a still larger growth, and that it is destined to become the busiest commercial centre in the United States.

---

### U. S. Government Installs Hydraulic Forging Presses at Mare Island Navy Yard

One of the United Engineering & Foundry Company's high-speed steam-hydraulic forging presses was put in operation on March 6 at the Mare Island Navy Yard of the United States Government. This company also put one of these high-speed presses in operation at the works of the Titusville Forge Company, at Titusville, Pa., on March 7, and on March 8 shipped one to the Westinghouse Electric & Manufacturing Company, at East Pittsburg, Pa., which will be in operation April 1.

The first press mentioned is of the single-frame type, 300 tons capacity, and the other two presses are of the four-column type, for 1,000 tons capacity.

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### Emptying a Flooded Tunnel

The latter part of April, what came near proving a serious accident, with considerable loss of life, took place in the construction of the great tunnel for the Catskill aqueduct, now being bored at Storm King, on the Hudson River, N. Y.

While blasting in the solid rock 1,100 feet below the water level and 350 feet out from shore a seam was opened in the rock, and the water came through into the tunnel, filling rapidly both it and the shaft.

At the time one hundred men were at work in the tunnel, but, fortunately, all escaped.

Four days after the seam was opened the flow of water was almost as fast as the quantity which the engineers were able to pump out, though every effort was being made to empty the tunnel, the well-known Cameron pumps being used for the purpose. These pumps are now win-

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ning out in the fight and clearing the tunnel of the inflow.

---

### New Company Incorporated to Act as Selling Agent Throughout the World for Ferrovanadium

The Universal Vanadium Company has been formed for the purpose of acting as selling agent throughout the world for ferrovanadium manufactured by the American Vanadium Company, Pittsburg, Pa., and will act in conjunction with the Vanadium Sales Company of America. It has been incorporated under the laws of Delaware. The directors and officers are as follows: Edward M. McIlvain, president, 30 Church street, New York; Col. Millard Hunsiker, vice-president, 23 Rue De La Paix, Paris, France; James C. Gray, secretary and treasurer, Frick building, Pittsburg, Pa.; Joseph W. De Wyckoff, European representative, 64 Victoria street, Westminster, London, England; E. Marshall Fox, Wetley Rocks, Staffordshire, England; Sylvester D. Townsend, Jr., Wilmington, Del.; William McIlvain, Reading, Pa.

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Rodman Gilder, secretary of the Crocker-Wheeler Company, manufacturers of electrical machinery, Ampere, N. J., has resigned, to become associated with the well-known brokerage house of Dick Bros. & Co., 30 Broad street, New York. His seven years' experience in a high-class industrial concern should be of value to him in the analysis of bonds of industrial and other corporations, such as are handled by the bond department of Dick Bros. & Co.

---

### Jenkins Brothers' New Quarters

Jenkins Brothers, whose valves and packing are so widely used throughout the world, have been forced by the great growth of their business to move from their old location at 71 John street, where they were located for thirty years, to larger quarters, and are now located at 80 White street, New York, N. Y., where they have secured the increased facilities they required to keep pace with the steady, constant growth in the demand for their products.

---

The Northern Indiana Gas & Electric Company, of Chesterton, Ill., has ordered two 3,750-Kva. steam turbines from the Westinghouse Machine Company. The turbines will operate on a steam pressure of 175 pounds (100° superheat), and will exhaust into a vacuum of 28 inches. The turbines will be connected to 750-Kva., 13,200-volt, 3-phase, 60-cycle Westinghouse generators.

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Dr. Charles P. Steinmetz, of the General Electric Company, recently delivered a series of two lectures on "Electrical Energy" before the students of the College of Engineering of the University of Illinois.

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### Economical Power

An exceedingly interesting series of letters, from the purchasers and users of their gas engines and gas producers, is issued by the Jacobson Engineering Company, of Saratoga Springs, N. Y., wherein a number of engineers give actual figures showing a very considerable saving in coal consumed, an example being the statement of the engineer of the Baltimore Grain Clearing House, who states that their coal consumption is about 60 pounds per hour, where it would be not less than 500 pounds per hour if they were operating a steam plant of the same size. These letters will prove interesting reading to those who are interested in economical production of power.

---

### The Sterling Machine Company Erect New Plant at Norwich, Conn.

The Rochester Machine Tool Works Company, owing to the constantly increasing demand for their Acme automatic steam engines and Buckeye patent water-tube boilers, have erected a new plant at Norwich, Conn., which has been equipped with the latest and most up-to-date machinery, and at this new plant, under the

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The molds for molding squares, hexagonal and many other styles of mosaic floor and sidewalk blocks are fully illustrated and explained. Price...............**50 cents**

**CONCRETE SILOS**
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**CONCRETE CHIMNEYS, SLATE AND ROOF TILES**
By A. A. Houghton
The manufacture of all types of concrete slate and roof tile is fully treated. Valuable data on all forms of reinforced concrete roofs are contained within its pages. The construction of concrete chimneys by block and monolithic systems is fully illustrated and described. A number of ornamental designs of chimney construction with molds are shown in this valuable treatise. Price................**50 cents**

**MOLDING AND CURING ORNAMENTAL CONCRETE.**
By A. A. Houghton
The proper proportions of cement and aggregates for various finishes, also the methods of thoroughly mixing and placing in the molds, are fully treated. An exhaustive treatise on this subject that every concrete worker will find of daily use and value. Price..................**50 cents**

**CONCRETE MONUMENTS, MAUSOLEUMS AND BURIAL VAULTS**
By A. A. Houghton
The molding of concrete monuments to imitate the most expensive cut stone is explained in this treatise, with working drawings of easily built molds. Cutting inscriptions and designs is also fully treated.
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name of "The Sterling Machine Company," their engines and boilers are now being made.

All communications intended for the Rochester Machine Tool Works should now be addressed to the Sterling Machine Company, Norwich, Conn .

## BOOK NOTES

**"Popular 50c. Hand-Books for Concrete Users**

A series of practical monographs on popular concrete subjects has just been issued. They are prepared by the well-known expert, Mr. A. A. Houghton. Each book of the series is fully illustrated, and the subject of which it treats is exhaustively treated in plain English, so all can easily understand the valuable ideas presented. Perhaps of this series the most popular book is the one entitled "Concrete Floors and Sidewalks," a work fully illustrated and selling for 50c. This is a reference book, written in simple but forceful language, to meet the requirements of those for whom it is intended. The writer has not only treated of the subject of moulding concrete floors and sidewalks comprehensively, but has gone into the production of the more ornamental effects made possible by employing mosaic concrete floor tile. The rules of construction are taken up in regular order as the work should progress, treating of the essential points on foundations and the placing of the forms, as well as materials, proper proportioning and mixing, placing and tamping, size of slabs, joints, and finishing the surface. Causes of defects are also outlined. More detailed work on floors and sidewalks is gone into, but the above gives the essential points of the book. A valuable addition to anyone's library. Published by the Norman W. Henley Publishing Company, 132 Nassau street, New York, from whom copies can be obtained at 50c. each.

"Popular Hand-Book for Cement and Concrete Users," by Myron H. Lewis and Albert H. Chandler. 430

pages, 126 illustrations, bound in cloth. Published by the Norman W. Henley Publishing Company, 132 Nassau street, New York. Price $2.50.

At the present time there is a great need that laymen, small contractors, masons, and other non-technical men who are interesting themselves in the construction of concrete should have a better knowledge of the subject than they ordinarily have, because it seems safe to say that ignorance is responsible for more errors in concrete building than intent to defraud. A book, therefore, that will help these men to an appreciation of the difficulties in concrete work, as well as the extent of its possibilities, has a certain value, and such a book is the one given above. This is certainly a popular hand-book on concrete topics, and everyone interested in the subject should at once procure a copy.

---

"The Strength of Oxyacetylene Welds in Steel," by Herbert L. Whittemore, has just been issued as Bulletin No. 45 of the Engineering Experiment Station of the University of Illinois. This bulletin gives the results of an extensive series of tests to determine the strength which may be developed in welded joints made by fusing thin steel plates together by means of the flame of an oxy-acetylene blowpipe. It was found that, with careful manipulation, such a welded joint may be expected to have about 85 per cent. of the strength of plate material.

Copies of Bulletin No. 45 may be obtained gratis upon application to Prof. W. F. M. Goss, Director of the Engineering Experiment Station, University of Illinois, Urbana, Ill.

---

An attractive illustrated book has been issued by Mr. Charles T. Main, the well-known mill engineer and architect, of Boston, which describes some twenty-odd representative plants selected from many installations made by him during the past four years.

**25c. Books on Practical Subjects**

**BRAZING AND SOLDERING**
By James F. Hobart
The only book that shows you just how to handle any job of brazing or soldering that comes along; tells you what mixture to use, how to make a furnace if you need one. Full of kinks. Fourth edition.
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By Fred. H. Colvin
There are two ways to turn tapers; the right way and one other. This treatise has to do with the right way; it tells you how to start the work properly, how to set the lathe, what tools to use and how to use them, and forty and one other little things that you should know. Fourth edition.
Price........................**25 cents**

**DRAFTING OF CAMS**
By Louis Rouillion
Every mechanic is interested in Cams, and this shows just how to lay them out for any kind of work you may have. There is more real information in this little book than in others that cost more. Third edition. Price................**25 cents**

**THREADS AND THREAD CUTTING**
By Colvin-Stabel
This clears up many of the mysteries of thread cutting, such as double and triple threads, internal threads, catching threads, uses of hobs, etc. Contains a lot of useful hints and several tables. Third edition.
Price........................**25 cents**

**COMMUTATOR CONSTRUCTION**
By William Baxter, Jr.
The business end of any dynamo or motor of the direct current type is the commutator. This book goes into the designing, building and maintenance of commutators; shows how to locate troubles and how to remedy them; everyone who fusses with dynamos needs this. Fourth edition.
Price........................**25 cents**

**WIRING A HOUSE**
By Herbert Pratt
Shows a house already built; tells just how to start about wiring it; where to begin; what wire to use; how to run it according to Insurance Rules; in fact just the information you need. Directions apply equally to a shop. Fourth edition.
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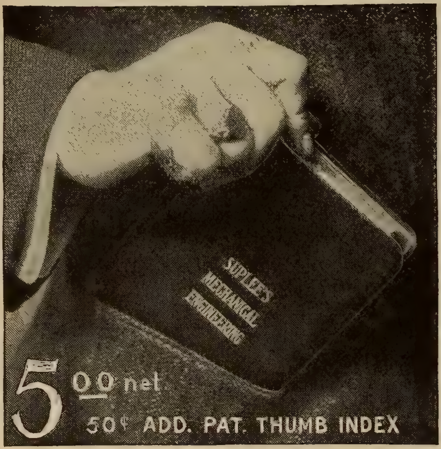

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From the Precision Instrument Company, of Detroit, Mich., is received a very completely illustrated catalogue of their indicators, gauges and recorders. In their "precision" line are included armoured case recorders, for use in exposed situations, such as blast furnaces, coke ovens, etc.; dead-beat recorders, for pressure or vacuum; dead-beat portable recorders, which work without any liquid and have incorrodible working parts; continuous "tape" recorders, on which the record is made on a tape which can be torn off every twenty-four or forty-eight hours, or at any desired interval, yet the roll only requires renewing every sixty days, or six times a year, instead of every day, thus avoiding the trouble of recharting and setting; dead-beat indicators, dead-beat draught gauges and portable draught gauges, open scale recorders, portable registers, dial gauges, detachable gauges, water-tube pressure gauges, etc.

They guarantee the accuracy of every instrument they manufacture, and use only the very best materials and workmanship.

Their catalogue is exceedingly valuable and well worth sending for. Copies may be obtained by addressing them.

---

**Boiler Makers' Tools**

Catalogue 27 is received from J. Faessler Mfg. Company, Moberly, Mo. It describes the well-known line of boiler makers' tools made by them, a class of product they have specialized on for over thirty years.

This work is fully illustrated, and can be obtained by addressing them.

### Bristol's Class III Recording Thermometers

A new 40-page illustrated catalogue has been issued by the Bristol Company, of Waterbury, Conn., of Bristol's Class III. recording thermometers, which includes descriptions and lists of the compensated gas-filled recording thermometers which were discussed in recent issues of a number of the engineering papers. These instruments are being used for a great variety of applications for recording temperatures up to 800° F. A number of the most important applications are mentioned on page 35, and the catalogue contains much of interest. A copy can be obtained on request, and it is well worth writing for.

---

### The Bruce-Macbeth Gas Engine

A catalogue descriptive of their gas engines has been received from the Bruce-Macbeth Engine Company, of Cleveland, Ohio. It is a handsomely printed and illustrated book of over 30 pages, and contains much of value to the manufacturer who is endeavoring to solve the imperative problem of cutting down costs. The company will gladly send a copy on request.

---

New catalogue sections have been issued by the Schutte & Koerting Company, of Philadelphia, as follows: Hydaulic operated free exhaust valve for turbines, Koerting air-jet chimney ventilators, S. & K. automatic engine lubricator, Koerting grease extractor and feed-water filter, S. & K. blast governors for Corliss engines, and S.-K. vacuum breaker valves.

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### Wires and Cables

The General Electric Company recently issued Bulletin No. 4,787, which is an exceedingly handsome and valuable work devoted to the subject of wires and cables. The publication should be of considerable service to purchasing agents, central station managers, and all having occasion to buy or use wire and cable for any service. The book contains much data, but no prices.

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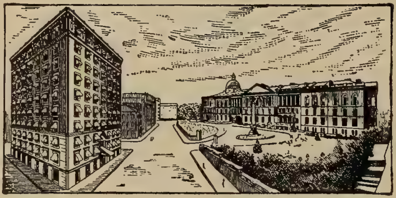

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**L. W. TULLER, Prop.**

An exceedingly artistic and handsomely illustrated book of 100 pages is just received from the Nicholson File Company, of Providence, R. I.

In the present day, when the art of catalogue-making is so far advanced, the production of a catalogue that commands immediate attention through its beauty requires much skill and taste, and the Nicholson File Company are to be congratulated on the success they have achieved in this respect—a success which is only equaled by that they have already achieved in the manufacture of machine-made files.

The book is bound in a handsomely embossed gray cover, the gray scheme being carried out throughout. Half-tones are shown of their different plants, as well as some of the high-grade files and rasps they manufacture for every possible use, and as the page is 8" x 10½", sufficient space is provided for large and effective illustrations.

An interesting chapter contained in the book is entitled "The Nicholson File Company and Its Founder," which gives many historical facts relating to the growth of the company since its incorporation in 1864.

Before Mr. Nicholson's death, in 1893, he had seen the capacity of his company's works at Providence increase from the small beginning to over 1,500 dozen files per day. The company at present, in their Providence factories, alone manufacture over 3,500 different kinds of standard files, each file being required to fulfill Mr. Nicholson's original belief, that only the best should be produced and that a uniform quality and one that would give the greatest efficiency was the requisite of the truly cheap articles.

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**Recording Voltmeters**

Bulletin No. C 131 has just been issued by the Bristol Company, of Waterbury, Conn., and is a 44-page, illustrated catalogue of Bristol's recording voltmeters for switchboard and portable service, with 12-inch, 8-inch and 6-inch charts, and contains a partial list of about 1,000 users of their voltmeters.

# AIRSHIP "DEUTSCHLAND" WRECKED

After a career of six weeks, the "Deutschland," latest of the models of Count Zeppelin's ill-fated dirigible balloons, was stranded on May 16 on the roof of its shed and became a total wreck.

The finish of the airship was less spectacular than that of its predecessors, but more complete. Fortunately, the crew and passengers escaped injury.

The accident occurred as the "Deutschland" was being released for a passenger trip. Eight passengers, four men and four women, had seated themselves in the cabin, the crew were at their posts, and 200 men on the ground clung to the guideropes as the craft slowly emerged from her berth, and, under pressure of over half a million cubic feet of gas, struggled to be free.

Just as the airship cleared the shed a violent gust of wind drove her back against the entrance. At the impact several of the balloonettes burst, and the released gas destroyed the equilibrium. The army of men at the guideropes clung on desperately, but were powerless against the wind, and another gust lifted the airship bodily and dropped her upon the roof of the shed, her back broken and her hull left dangling over one edge.

In this position the crew and passengers, rudely shaken, but not seriously injured, were left helpless until firemen, hurriedly summoned, ran their ladders to the top of the balloon shed and pulled the marooned persons out of the wreck.

The "Deutschland" made her maiden flight March 30, and some idea of its great size can be gained from the following dimensions: She had a length of 486 feet, a diameter of 47 feet and a volume of about 675,000 cubic feet, her buoyancy being derived from eighteen separate gas reservoirs that were embedded in a section of the airship's body between two transverse rings of the aluminum framework.

The passenger cabin was suspended between the two engine cars in the middle of the ship, and was designed to comfortably accommodate twenty passengers. The cabin was furnished with comfortable wicker chairs. All the metal portions in the interior were covered by mahogany, and the panels, ceilings and other woodwork were of the same material. Large sliding windows admitted of an unobstructed view on all sides.

The Hamburg-American Line had planned to book passengers for the excursions of the Zeppelin airship "Deutschland," which was owned by the Deutsche Luftschifffahrts-Aktien-Gesellschaft (German Airship Navigation Company, Ltd.), of Düsseldorf.

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The Society of Arts of the Massachusetts Institute of Technology, Boston, Mass., has started a new monthly publication called *Science Conspectus.* The editors state in the first number:

"In enlarging the scope of the publication of the Society of Arts it is our aim to give, as far as we may be able, a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and, in general, we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in *Science Conspectus* will not be printed simply because it is available, but will be carefully selected, and, wherever possible, will be amply illustrated."

## Efficiency in Transport

FROM the various discussions of efficiency in works management which are so plentiful nowadays it might be presumed that nearly all manufacturing operations were performed by hand, and that all that was necessary in order to secure the greatest advantage was to develop the efficiency of the workmen themselves.

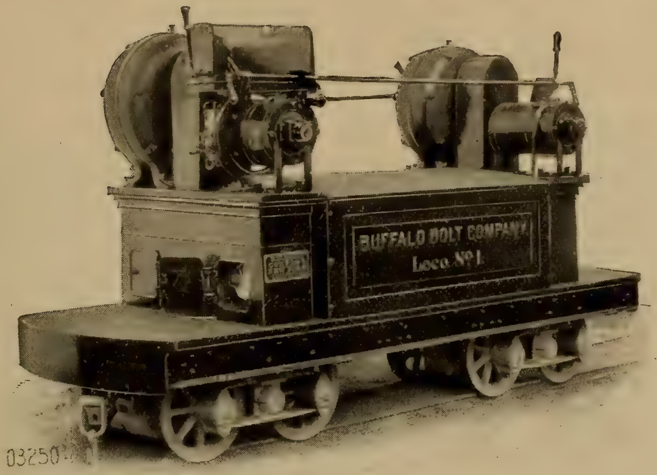
As a matter of fact, it has long been realized by the most successful managers that one of the desirable things to accomplish is the substitution of mechanical appliances for manual labour wherever possible, not only because of the increased capacity of the machine over the man, but also to reduce the difficult human element as much as practicable. Increasing the efficiency of a man is not always so desirable as the avoidance of the man altogether, and even if the remaining men who are employed are not of maximum efficiency the reduction in their numbers and the introduction of the far more efficient machine for the greater proportion of the work effect economies of especial value.

There is probably no department of shop work for which human labour is less fitted than for the moving of heavy loads. Men who do this kind of work are usually called "labourers," in distinction from those of greater ability, such as skilled machinists and attendants upon productive machines. Nevertheless, the modern processes of manufacture involve such a continuous and active movement of material in the various stages, from the raw state to the finished product, that the daily "traffic," as it may be termed, forms a very important part of the entire process, and unless the efficiency of this element be maintained at a high point it will detract to a marked degree from that of the actual machining operations. The modern shop simply cannot afford to have its products moved along by human muscular effort.

This question of transport has been fully solved for the individual upon the highway by the introduction of the automobile, and for the delivery department of the merchant by the development of the motor truck, while the problem has been solved most effectively for the manufacturing establishment by the production of the industrial railway. In the modern establishment there has been made possible a complete system of internal transport, including standard track, curves, turnouts, switches and equipment, permitting efficient transport to all parts of the shop floor, and also between all buildings constituting the establishment. This alone has effected a great increase in efficiency over the old-time crude method of hauling material about upon ordinary trucks over the shop floor, but it forms only a portion of the complete system as at present developed. Even with the proper cars, upon an industrial railway system, the demands of the efficient factory call for power traction, and in response to this demand the storage-battery locomotive has now been produced.

Thus there is available a complete system of power traction for shop service which reduces the number of men engaged in this department to a minimum, and substitutes for their inefficient and expensive efforts the wholly satisfactory industrial system, and effects within the walls of the workshop as complete a revolution as the introduction of railways produced over the external world.

It is by such scientific methods that maximum shop efficiency may be attained, removing, as much as possible, the fallible and variable human element, and replacing it by mechanical appliances of known and determinate efficiency and using the services of highly skilled mechanics—men who work with their heads as much as with their hands—to effect the results which cannot be accomplished by mechanical appliances alone.



# Hunt Storage Battery Locomotive

21½ Inches Gauge

**WRITE FOR NEW CATALOGUE 068**

WRITE for this Catalogue if you want to find out the most efficient and economical method of transporting raw and finished materials in and around your Works or Factory. The financial success of a business sometimes rests on one item—the working expenses—and a very marked reduction can be effected by using a Hunt Electric Storage Battery Locomotive. At one plant this locomotive displaced eight men and one horse. Coupled to six cars each carrying one and one-half to two tons, the locomotive made a round trip in eighteen minutes. It had previously taken one hour to cover the same distance with a horse. The same locomotive hauled a train of cars up a grade on a curve, work which had previously required the services of ten men. It goes around curves as easily as a wagon turns a corner. A Storage Battery furnishes the power, and is recharged during the night or during the day when the locomotive is not in operation. It is ready for use at any time of the day or night and power is used only when the locomotive is in operation. It is cheaper to maintain and operate than a span of horses. As no trolley wires are required the locomotive can reach any part of the buildings and yards either on the permanent or on temporary tracks. If you wish to reduce the expense of handling materials in your Works or Factory, write to-day for Catalogue 068.

**C. W. HUNT CO., West New Brighton, N. Y.**

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## Mechanical Cost Keeping

NEARLY every modern machine shop has installed its own system of cost keeping, not only for finding out what it is receiving from its employees in return for the wages they are paid, but also to enable them to make such prices for their products as will cover the manufacturing costs and enable a fair profit to be returned on the business.

The old methods of cost keeping took into account the labour, the material and a certain rather arbitrary element, intended to cover the so-called "general expense," the expenditure which could not be directly computed as a productive portion. More recently it has become general to include a "machine rate," this including an hourly charge for the machine tool by which the work is performed, and being based upon the amount invested in the machine, its depreciation, and its estimated earning capacity.

This latter principle, when once conceded, must naturally be extended much farther than was at first presumed. If a lathe, or planer, or milling machine is to be considered as having an earning value, to be charged against the product which it turns out, why should not the same method of procedure be extended to other tools, even though they do not remove material or leave their visible impress upon the finished product?

Anything which influences the actual cost of performing the work should be taken into account if the true shop cost is to be correctly ascertained. The labour cost includes not only the work of the machinist who places the piece in the lathe or planer, who sets the tool, who gauges the cut and who controls the actual machining; it also must include the physical labour of the man who lifts the work, hauls it through the shop and who removes it from the machine to make place for its successor.

These questions of handling play a most important part in the actual cost of the work, not only in the elements which they involve directly, but also in their influence which they exert upon the entire sequence.

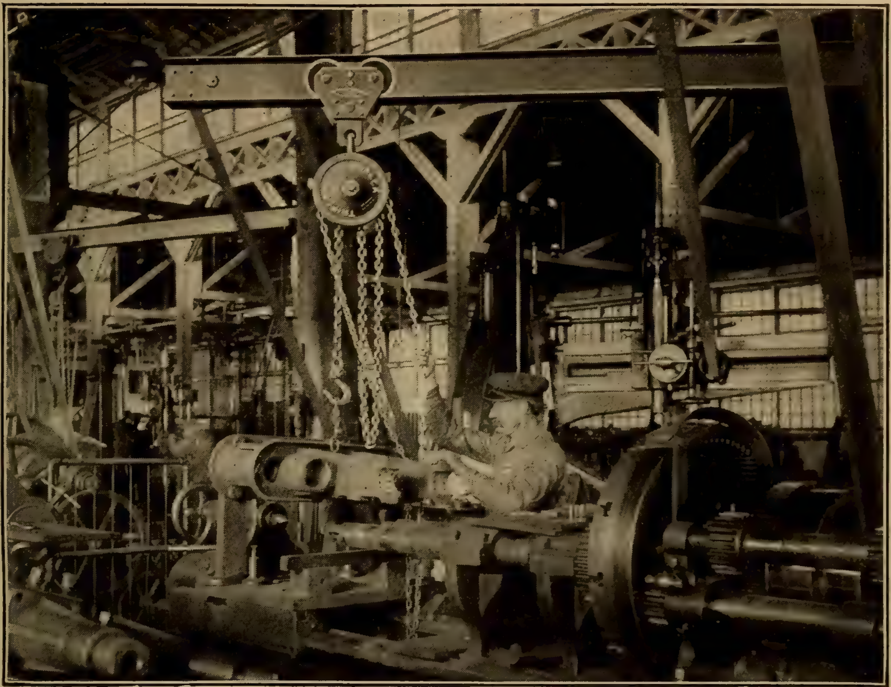
The high cost of modern machine tools and the rate of wages paid to skilled operators both render it necessary that every moment of their time should be employed in productive work. If the machine and its operator are obliged to be idle while waiting to receive work or to permit the removal of finished products, the loss becomes cumulative, and includes not only the services of the labourer, but involves charges for idle time both of machinist and machine.

These losses are no speculative amounts; they are capable of precise determination. It is necessary only to note the time required in lifting the work—time demanding idleness of expensive tools and employees who are waiting—to perceive just what such operations cost.

Admitting the cost of such elements of manufacturing, it remains only to consider the method by which they may be minimized. To keep labourers busy in order that machinists and tools may be idle is certainly poor management, and the converse forms one of the fundamental principles of scientific management. If every tool is provided with mechanical appliances, such as highly efficient hoists and trolleys, enabling the operator himself to use his highly developed intelligence, aided by apparatus of precision and accuracy, the labourer may be dispensed with, the machine tool kept busy continuously, and the burden upon the product limited to the elements which are actually productive.

In such methods the Triplex Block has shown its peculiar value, not only by reason of its inherent high efficiency, but by its capacity to utilize the efficiency of others. The efficiency of any series of operations depends upon the efficiencies of all of its elements, and any defective detail pulls down the final result in a manner which needs only to be investigated to be appreciated.

# THE TRIPLEX BLOCK



A Triplex Block hung from a trolley running on an overhead bracket crane and used for serving a machine tool.

## You Can Actually Figure This Saving in Dollars and Cents

JUST note the time saved in lifting a casting—in adjusting it for the operations—and in removing it from the tool. It's not much trouble to convert that time into dollars and cents.

And this saving is effected by one man, with a Triplex Block rigged up as in the picture above. He can handle castings up to several tons in weight, without assistance, and with an ease of operation and control not found in any other lifting device.

Thousands of these installations are in daily use. We should like to talk figures with you on any lifting problem.

But whatever you do, send for the Book of Hoists to-day.

**Triplex Blocks** { **16 Sizes:** One-quarter of a ton to forty tons.
**300 Active Stocks** all over the United States.

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## Defenses Against Danger

THE ordinary idea of defense is that of the interposition of some obstacle against an attack—the shield of the old-time warrior, the wall of a fortification, the steel armour of a battleship. There are dangers of other kinds, however, against which different kinds of defenses become necessary. We all know how modern medicine is working with preventive methods against disease, and these methods are as much defenses as the quarantine wall or the isolation hospital. There are other instances which might be enumerated, but even these defenses are, in principle, intended to oppose attack and operated upon that idea.

There is now before the community a realization of another kind of danger, demanding a different kind of defense. Nearly every industrial operation involving the use of mechanical power necessarily places the operatives in the midst of powerful machinery, including mechanism capable of doing things far beyond the powers of unaided human effort, and this giant of mechanical power, tamed and controlled, is a source of wealth and civilization. If, however, by any reason the power thus applied becomes accidentally diverted, or if an operative becomes entangled in machinery, there follows injury, disaster, and possibly death. The records of manufacturing include a mortality list comparable with that of disease, but, apart from remedial efforts, demanding a wholly different kind of treatment.

We have, therefore, a special department of defense to be developed, a defense against accidents to employees, both in connection with the design of operative machines and in connection with the generation and transmission of the power by which they are driven.

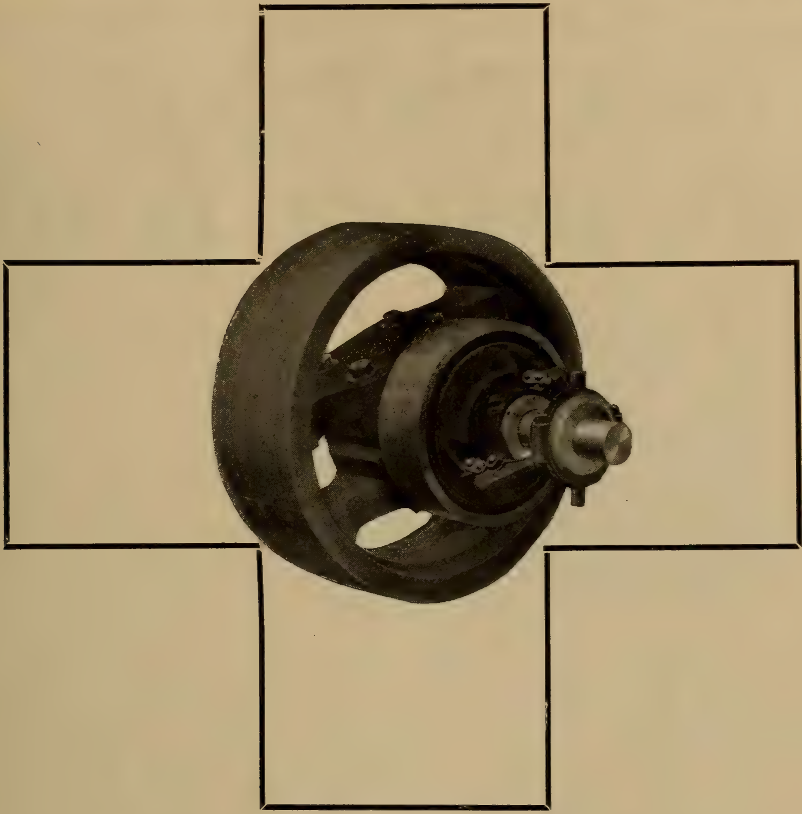
Leaving aside for the present the question of the proper guarding and shielding of the dangerous parts of machines as suitable for separate discussion, we may examine the proper method of defense against the dangers of transmission machinery and of the unguardable elements of machines themselves.

Modern transmission machinery is necessarily designed to be stiff, strong and smooth-running. This means that some little time must elapse before the entire system, from steam engine through to shafting, pulleys, belts and machines, can be brought to rest. During even a few minutes, even of a slowing movement, the fatal or disastrous force may be exerted, while a prompter control at more immediate service would have been the real and effective defense. If the giant could be compelled to release his hold immediately he might safely be quieted down, if necessary.

The proper defense thus indicated must be obvious. The means of prompt release of motion in any department of an establishment should be provided independently of any communication or response from the distant source of power.

Most mechanics think of a clutch as something which "holds on," and the name clearly indicates this idea; but the real clutch must be capable of letting go as well as of holding on. If it fails to hold on it will not only fail of its regular service, but may become itself a source of danger; to be wholly satisfactory it must be dependable to the last extreme in both of its functions, gripping when transmitting with an unfailing hold, and releasing fully and promptly when the sudden emergency call comes.

Here, then, is a defense against danger which, so far from being an obstacle, is a relief and cessation, a method of removing the opposing force, and thus a preventive measure of the highest value. However well machinery may be guarded, and however careful employer and employees may be, there will be occasions when the prompt stopping of the machinery becomes necessary, and in this method of defense a most powerful protection is readily obtainable.



# First Aid Before the Accident

**DODGE**

*The* time to *do something* in regard to factory accidents is *in* advance. ¶ Forethought is vastly better than loss of life or limb—damage to valuable machinery—or damages to pay injured workmen. ¶ The Dodge Idea in Power Transmission machinery contemplates *safety* first of all—and secures safety at a *saving.* ¶ It conforms to the rigid factory laws that *have been* passed, and the more rigid ones that *will be passed.* The trend of legislation is that way.

## Meet the Law's Demands

and at the same time gain in efficiency and independent department control by installing Dodge Split Friction Clutches. ¶ When something goes wrong—you can cut out the machine instantly before it does serious damage. ¶ Fatal results from accidents come most frequently from delay in shutting off the power.

¶ INDEPENDENT CONTROL IS THE THING. You get it at a *big saving* by using

## DODGE FRICTION CLUTCHES

¶ Power is confined to the places in operation instead of dissipating it through idle departments. ¶ Because of its split feature, Dodge Friction Clutches are easily mounted without disturbing any other equipment or taking down the shaft. ¶ Dodge availability is another important feature. Dodge dealers carrying in stock everything for the mechanical transmission of power are located in all the leading cities. And because Dodge equipment is as far as possible *interchangeable*, you can use it again and again in different places. ¶ Dodge Service further means the scientific advice of a staff of expert engineers for the asking.

¶ Write for our special literature on the *life-saving, machinery-saving, power-saving, money-saving* value of Dodge Friction Clutches.

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## Quarrying by Air and Electricity

THE work of the rock channeler is simple enough in the essential idea of it—just cutting slits in bed-rock, normally vertically downward and extending considerable lengths horizontally, but also at all angles, from the vertical to the horizontal. The facility with which it does this special line of work has made the machine of the greatest importance, and now it is indispensable to the quarrymen for getting out stone according to requirements and to the engineer for securing smooth sides to rock-cut canals and aqueducts.

Few of our industrial operations can enumerate so many important collateral advantages resulting without some offsetting considerations. Not only is the element of chance eliminated in the size and shape of stones produced, so that they require a minimum of work for the ultimate dressing and finishing, but at the quarry the waste to be disposed of is reduced to the smallest possible amount and the condition of the bed is as good as, or better than, before for subsequent operations.

The channeler being accepted as a necessary detail of the equipment of the up-to-date quarry, the most important consideration in connection with it is as to the drive of it. In this the channeler is not to be considered alone, but in connection with the entire power equipment and the requirements of all the apparatus employed, to which it should be able to accommodate itself without sacrifice of efficiency.

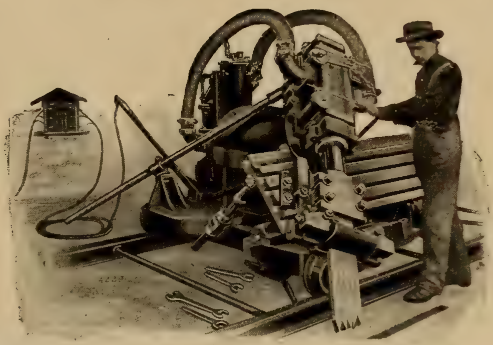
The first channelers were steam-operated, generally having their own boilers and enabling the machines to be located and operated in positions otherwise not practicable. This, however, could not long satisfy the devloping conditions. The pushing habit of electricity has brought it to the quarry also, and it has become very desirable in many cases, on account of the out-of-the-way location of the work or the large water-power available at a convenient distance, to employ the electric current for all power requirements.

This has hitherto been impossible on account of the rock drills and the channelers, which have insistently required either steam or air. The most persistent experimenting and the most ingenious inventing and designing have not brought a successful directly-driven rock drill in sight, and, the operating conditions of the channeler as to power application being identical, it has been in the same category.

Following only tradition and habit, without any persistent attempt at simplification, it might easily have happened, and in some cases it did happen, that steam and air and electricity were all used in the same plant for different details of the work. If one medium could have been employed for all of the power transmitted instead of the three, the presumptive economy and convenience should be self-evident. Of the three, the one which now most strenuously refuses to be dispensed with is electricity, and in many cases the sooner it is adopted the better.

So far as the rock drill and the channeler are concerned, they have entirely ceased to embarrass us in the employment of electricity for driving. If electric current is the most available, the most economical, or in any way the most desirable power to be used in any given case, and if all the other apparatus can properly be electrically driven, then the electric driver is the best also for the drills and channelers. The electric-air principle as employed in both of these adapts them perfectly to the electric drive, not only without the slightest sacrifice of efficiency or convenience, but with a very appreciable and demonstrable saving of power for every unit employed. The electric-air drive is one of those inventions which *came all at once,* bringing all its advantages with it, some of them only revealed by actual experience after the event.

# "ELECTRIC-AIR" STONE CHANNELERS



## THE POWER SAVING CHANNELER

Cost of stone channeling is made up of three items—power, labor and up-keep. **The "Electric-Air" Channeler cuts the power cost without affecting the other two items.**

It is not telling the whole story to say merely that the "Electric-Air" Channeler uses a third to a half less power than any other channeler doing the same work—though this is a fact.

This saving is reflected in the entire plant equipment, for it means a smaller power installation and the elimination of piping throughout the quarry.

**The "Electric-Air" Channeler has every essential requirement of the most up-to-date channeling machine, with the additional and exclusive advantage of this great power saving.**

It is worth the investigation of every one who has a channeling problem.

**COMPRESSORS** **PNEUMATIC TOOLS** **AIR HOISTS**

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### Manufacturing by Machinery

IT is a curious fact that in the course of usage the meaning of words in common use often becomes wholly reversed from that indicated by the combinations from which they were originally formed. Thus, the word "manufactured" originally meant "made by hand." To-day this is precisely what it does not mean, as it is practically limited in general usage to machine-made articles, and not applied to the unaided products of the hand.

The factory system, however, has, until comparatively recently, been limited to the production of staple articles, and in the popular mind is associated with textile works and similar industries, which have been devoted to the production of great quantities of things of identical character intended to be distributed widely through the markets of the world, and has rarely been considered as relating to the operations of the machine shop or engineering works.

It is one of the changes in modern industry, however, which has been concerned with the development of certain machine tools which have rendered it possible to introduce manufacturing methods into general shop work, so that the term manufacturing by machinery has been extended far more widely than was formerly assumed.

Thus the ordinary engine lathe demanded especial skill on the part of the operator, both in the placing of the work and the setting of the tool. Successive operations required successive settings, while any attempt to obtain duplication or repetition of work for interchangeable construction demanded the highest degree of skill, accompanied by the use of accurate gauges and measuring appliances.

Even with the application of special skill at the lathe it was found that a certain amount of bench fitting was inevitable, and the actual result of these regular machine-shop operations was to cause the work really to be hand-produced, the machines only acting to remove the surplus material and not to control the final accuracy of the completed product.

With the demand for the extension of manufacturing and repetition processes to machine-shop work, however, there has been produced improved lathes, providing for the accurate reproduction of machined parts to a far greater extent than has hitherto been thought possible. These methods demand that many things formerly entrusted to the repeated judgment of the workman should be provided for at the inception of the work and then require no further attention. Thus the determination of lengths is settled by the adjustment of stops, which act thereafter to establish the distances of intermediate points and of total lengths positively, without requiring further attention until a new series of products is undertaken. By providing a turntable carrying a number of tools, arranged and adjusted beforehand and placed so as to effect the desired cutting operations in proper sequence, the precise character of a number of pieces is determined.

These are but elementary points which differentiate such a machine as the turntable lathe from the ordinary engine lathe, but when combined with increased stiffness and stability, and included in the modern arrangement of change gears and details for control and handling, they enable what were formerly manual operations aided by machine power to be converted into actual manufacturing.

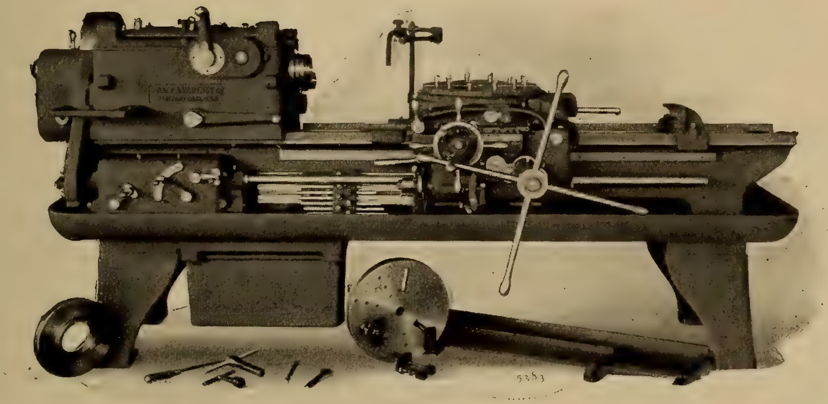
Therefore, the development of modern machine tools is leading up to the extension of the manufacturing principle into machine shop work to a greater degree than would formerly have been thought possible; and when combined with such judgment in design of the intended parts as to permit the production of numbers of each at a time there results a remarkable increase in efficiency.

**Heavy or Light—Large or Small Forgings, Castings or Rod Work**

done with equal accuracy and efficiency
on a

# P. & W. Turntable Lathe

**with Cross Sliding Turntable**



**A MACHINE FOR MANUFACTURING**

Solidly fastened head. All geared drive. Speed and feed changes instantly obtained through convenient levers.

Accurate and positive stop system ensures a degree of accuracy and duplication that eliminates all bench fitting.

**TOOL OUTFIT IS STANDARD**

**Write for Catalog "Turntable Lathe"**

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**HARTFORD, CONN., U. S. A.**

**SALES OFFICES:** New York, Boston, Philadelphia, Pittsburgh, Chicago, St. Louis, Birmingham (Ala.), Detroit, Cleveland, Hamilton, London.

### Workshop Chemistry

CHEMISTRY, the successor of the mediæval alchemy, has always been supposed to be a sort of mysterious science—an art by which man might combine elements of various kinds, either rare or plentiful, and produce remarkable results. It is true that many most valuable combinations have been made as a result of the work of the chemist, and we need only consider such industries as the manufacture of rubber or the numerous departments of metallurgy to realize the great commercial value of chemical industry.

It is now beginning to be appreciated, however, that the operations of chemistry are not confined to the secluded rooms of the laboratory, but that their field has been extended to the workshop, the iron foundry and the steel mill, and that the laboratory itself may be only the ante-room through which the work of the chemist passes before it reaches the workshops of the world.

There is probably no department of work in which these facts are more fully appreciated than in the production and use of the so-called alloy steels and in the ferro-alloys, by means of which the special alloys are made available for use to the practicable mechanic. Such a valuable material as vanadium steel, for example, must be produced with all the care and accuracy which characterize the work of the skilled chemist. The proportion of vanadium must be correct, and there must be no deteriorating elements present to oppose the toughening and strengthening action of the element which is thus introduced.

The foundryman or the steel maker cannot be expected to control, of his own motion, these important details; he is operating on too large a scale and in too broad a manner to be expected to obtain laboratory results by himself. It is, however, wholly practicable for him to produce the alloy steel, containing the correct percentage of vanadium and remaining free from deleterious ingredients, if he avails himself of the ferro-alloy prepared by the competent chemist from proper materials.

If we add a certain amount of ferro-vanadium, containing a precisely ascertained proportion of vanadium, to a given weight of steel, we know positively the percentage of vanadium in the resulting product. This means that the ferro-vanadium should have been carefully analyzed and its composition accurately known. Under such conditions the operation in the workshop is as truly a chemical operation as if conducted on a small scale in the laboratory. The work of the laboratory chemist has been transferred to the shop and its scale enormously increased without in any way diminishing its scientific accuracy. Guess-work is thus eliminated, and the large operation made as precise as the small one.

Until recently, the usefulness of the chemist in the steel works has been analytic, examining materials and products and determining how closely they conform to standards and requirements. Under modern methods, however, the chemical work has become synthetic in its character, enabling definite products to be made by adding to large quantities of crude material the necessary proportion of accurately compounded alloy, and giving as a final product the well-defined substance, having the mechanical properties demanded by specification, because it has complied with the necessary chemical and physical operations.

The design of parts of machines has thus become a definite and controllable question, since the strength and toughness of the material have been brought under control, and the stresses being known the dimensions may readily be computed. All depends upon the reliability of the alloys employed in the manufacture of the final material of construction, and when uncertainty is eliminated from this element of the work the whole problem becomes definite.

# VANADIUM

## Efficiency

Vanadium Steel keeps locomotives on the road where they ought to be, and out of the shop, where they ought not to be.

Vanadium Cast Steel frames are as strong as carbon steel forgings, their average tensile strength is 80,975 pounds and the average elastic limit 45,024 pounds. These averages were obtained on more than a thousand frames now in satisfactory operation on twenty-two of the best railroads in the country.

Wherever iron or steel fails by wear, crystallization and breakage, Vanadium Steel will succeed because of its strength, toughness, durability and anti-fatigue qualities. Greater efficiency, a higher factor of safety and less cost for repairs always result from the use of Vanadium Steel. Booklets free.

## American Vanadium Company

**Miners of Vanadium Ores**
**Largest Producers of Vanadium Alloys in the World**

**Entire Product sold by the**
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**335 Frick Building Pittsburgh, Pa.**

You cannot make good Vanadium Steel without good Ferro Vanadium. A full knowledge of the analysis of Ferro Vanadium is essential to guard against the introduction of impurities that will damage your steel more than the Vanadium will improve it. Ferro Vanadium containing carbon is almost worthless.

"Amervan" Ferro Vanadium is the result of years of careful and scientific experiments. Every shipment is analyzed and its composition is known exactly. There is no guess work and you run no risk of spoiling an entire heat of metal.

"Amervan" Ferro Vanadium is made in the largest factory in the world for the production of Vanadium Alloys, a factory that makes nothing else but Vanadium Alloys and always makes them right.

### Evidence in Open Court

THERE has been a sort of skepticism among merchants and business men generally as to the practicability of the motor-driven truck for commercial purposes, a skepticism naturally accompanying that degree of conservatism which men of large affairs usually possess. Such a conservatism investigates carefully any new development before taking it up extensively, and adopts important changes in methods only after being fully satisfied that they are real improvements.

The advantages and shortcomings of the horse-drawn truck are well known, and this old-established method of merchandise transport has been retained hitherto because, in spite of its defects, it was so familiar, and, in general, so practical. A machine doubtless had its advantages, but it seemed too much like an experiment to find immediate favour with the practical man.

A period of education and of demonstration has followed the original idea of using motor-driven vehicles for hauling merchandise and for making deliveries. This educational process has really followed the developments in manufacture, the present motor-truck, as applied in the service of many leading establishments, being the result of the concentration of engineering ability and manufacturing facilities, while the demonstrations of its value have been those of actual work rather than of exhibition tests.

The requirements of commerce as regards a motor vehicle are definite and intelligible. It is essential that such a machine should have greater capacity and speed than an ordinary horse-drawn vehicle, but these conditions alone would not suffice to make it acceptable. Above all things, the machine must be reliable; nothing can redeem uncertainty as to operation. This means that both engine and transmission must be free from complication, sturdily built, and wholly accessible for care and examination. It is also essential that a motor truck should be durable, since the return upon the investment must be made during the effective lifetime of the vehicle, and this lifetime must necessarily be longer than may be considered essential for a pleasure vehicle, subject to changes of style or season. When the question of efficiency comes up it naturally involves comparison with the operative cost of the horse truck, and experience now available with the motor truck has demonstrated the vastly superior efficiency of the machine over the animal. The real point which determines the question in most cases appears to be the desire of the merchant or manufacturer to be assured of the reliability of the machine.

The best assurance which can be given in this essential matter, aside from the knowledge of the expert and builder as to the correctness of design and excellence of construction, is found in the practical test of actual service in the work of eminent and critical users. The time has now arrived when assurance of this character may be secured simply by exercise of ordinary observation. The best endurance runs are those made in daily work upon city streets and suburban roads, delivering commercial burdens for houses of national reputation. The best testimonials are those written upon the vision of the critical observer. The most positive evidence is not that given by the specialist upon a single case, but that of general observation on all sides and in many and varied instances.

These are the arguments which the motor truck is now able to present in making its claims for favour, and it is upon such arguments and upon such evidence that a wholly reliable verdict may be secured.

The only point which need be added in this respect is to emphasize the necessity of observing accurately and of following the precedents which have proved successful with users in solving problems of merchandise delivery.

Part of the W. & J. Sloane Equipment, New York, N. Y.

## The Evidence is All Around You

You, the progressive men of the country, have been looking for a commercial motor-driven truck—you've placed the emphasis on "commercial" —wanted it understood that you were looking for a practicable, dependable, durable motor vehicle. Probably you even let it be understood that when the right one came along—the one upon which you could fully rely you would buy it. The evidence that such trucks are already here is all around you—solving some of the largest delivery problems. The findings of these large concerns is pretty likely to be right owing to the size and importance of these deliveries to their owners. What White trucks can do for such concerns as W. & J. Sloane and the Standard Oil Company of New York, for the Joseph Horne Company and the McCreery Company of Pittsburgh, for the Cleveland Akron Bag Company of Cleveland, for the Marshall Field Company of Chicago, or for the Auto Delivery Company of Portland, they will do for you. Further, these are but a few of the large users of White trucks.

## The Verdict is White Trucks

The verdict must always be in favor of White trucks if you will permit the evidence to be submitted, and the evidence is always the story of splendid performance. This performance is made possible by the design of the engine—its simplicity—its accessibility. The materials are the best that modern science knows—made into three sizes with the engine standardized in all. White trucks are unquestionably the most economical type of delivery yet devised for cartage work.

Let us supply you any information that
will throw light on your problem.

**The White Company**

832 EAST 79th STREET, CLEVELAND

### The Value of Service

EVERY employer of labour hires men and pays them wages in order to obtain their services, and, in general, the wage rate bears a relation to the value of the service returned. Sometimes this value is measured by time, sometimes in piece results, and sometimes according to a special system of remuneration; but the employer himself, in the ultimate analysis, is obliged to find out as accurately as he can the actual value to him of the service rendered, in order that he may know just what he is getting for the money paid out.

Under such conditions he must be guided by results in order to get the highest efficiency for his expenditure. It would be wasteful to employ a skilled machinist to do labouring work, and ruinous to pay such a low rate of wages to mechanics as to prevent acceptance by really skilled men. The wise manager chooses his employees according to the character of the service required, and in all cases, whatever the nominal system of remuneration, he himself has to consider the value of the service in connection with the final product.

These fundamental principles are true, not only of men, but of inanimate things, wherever they are employed in industrial operations.

Nearly every kind of material may be had in different grades at various prices, but the price alone is not the whole measure of value; it must be considered in connection with the suitability of the material for the service required. Cheap materials have their uses, just as untrained workmen may be usefully employed upon crude operations for which higher grades of labour would be too expensive. For some purposes the cost of the material is practically neglected, however high, since the real question is to obtain the result.

One of the elements of successful management lies in selecting men and materials according to the character of the result to be attained. By employing high-priced men to work with materials of great value correspondingly high-grade results are secured, but such a method would be impracticable for very many manufacturing operations. It has been well said that "good enough is the best," and when this maxim is rightly interpreted to mean that the grade, both of material and of workmen, should be selected for the grade of results required, its truth will be apparent.

For some departments of work it is immediately apparent which quality of material should be used for any given purpose, but with the high degree of differentiation prevailing in modern industry it is impracticable for any individual to possess such a wide range of information to do this in all instances. The same skill which is applied to modern manufacturing, however, is nearly always at the service of the user, and thus it has become possible to be advised directly by the manufacturer about the grade of product best adapted for each specified purpose. With concerns of high reputation such advice may be obtained by any purchaser as a matter of course, and, without additional cost, expert judgment fully equal to that which any specialist could furnish.

In such a matter as wire rope, for example, there are a number of varieties, adapted for as many varieties of service. The most economical kind, in every case, is that best suited for the work to be done, and any other would be less efficient.

One kind may be suitable for hoisting materials upon a crane or derrick, another for mining service, and yet another for the widely extending use, the track for an aerial cableway, the valued servant of the engineer and contractor.

If this principle of the value of service is kept in mind it would enable far higher results to be obtained in the long run than to adhere to any arbitrary standard, fixed according to some predetermined system, and unchangeable at the instance of specialized knowledge and judgment.

# THE PASSING OF AN OLD HOTEL THAT PLAYED AN IMPORTANT PART IN THE HISTORY OF THE NATION

THE progress and development of Washington have caused the demolishment of the old Riggs House, which played such an important part, not alone in the history of Washington, but of the nation itself.

Originally the Riggs House was a sort of Northern headquarters. This was in the '70's. In the early '80's the character of the Riggs House underwent a change. It became more the stopping place of the Western contingent.

In the days when the Riggs House drew the New Englanders and the New Yorkers and Pennsylvanians the sectional line was also closely drawn in other Washington hotels of the period. The Metropolitan was the Mecca for the Southern statesmen, near-statesmen and camp followers. In the National the Westerners found their abiding place.

The old Riggs House held the distinction of possessing the only billiard room in Washington ever frequented by a President of the United States. Here, in the early days of 1881, when he was but newly inaugurated to the Chief Magistracy, came James Abram Garfield, night after night, to play the game with his chums of his new administration.

Probably the most distinguished patrons who have ever made the Riggs House their permanent homes in Washington were Benjamin Harrison, of Indiana, and John G. Carlisle, of Kentucky. Mr. Harrison, while a Senator from Indiana, lived at the Riggs House for six winters. It was always headquarters for Carlisle. Both as Speaker of the House, and, later, as Senator, the Riggs House was his headquarters.

The suffragettes, in the days when they were called simple woman suffragists and before the patronage of the cult had become a fashionable fad, made the Riggs House their Washington home. Year after year Susan B. Anthony came to the old hotel. Earlier, Elizabeth Cady Stanton was with her. Frances Willard and other pioneers in the movement for the uplift of womankind knew the old hotel.

In the days when the four-cornered fight for the honor of holding the World's Columbian Exposition was being waged came George R. Davis, of Chicago, to the Riggs House. Here the schemes were hatched whereby the advocates of Washington and St. Louis were pledged to make Chicago their second choice. Here it was that New York, coming to Washington with a delegation headed by William C. Whitney, David B. Hill and Richard Croker, found the wires all laid for her undoing.

The financial world of the '80's made the Riggs House a sort of half-way house, and at the Riggs House were held the quiet conferences. Jay Gould stopped there invariably on his flying visits to the Capital. Russell Sage has occupied a room there on many nights following a busy day in communion with the political powers.

The Riggs House was erected in 1876. Prior to that time the site had been occupied by the Quartermaster General's office of the War Department. As such it weathered the storm of the Civil War.

At the time of its opening and for the first fifteen years of the historic career of the old house it was managed by C. W. Spofford. Orrin G. Staples, who now conducts the well-known Thousand Island House, at Alexandria Bay, N. Y., assumed the lease of the hotel May 4, 1891, and rounded out his twentieth year of proprietorship, and it was Mr. Staples who finally locked the doors of the old Riggs House for the first time since its construction.

### Scientific Savings

FEW people realize the important influence which the mere transference of a material has upon its ultimate cost. Coal may be purchased cheaply at the mine, but the moment it has to pass to some other place there is involved, not only the cost of railway transport, but, what are often far larger, the costs of handling at each end. One of the most prominent examples of the increase in efficiency by scientific management has been that of the economy possible in the proper shoveling of coal, but in the well-equipped establishment coal is no longer handled at all by any such primitive method as that of the man with the shovel; even at its best, such a system is far too costly.

The dealer, manufacturer, or shipper who realizes that his profits must come largely from his economies simply cannot afford to add to the cost of the material the excessive cost of moving it by hand; he knows that he must use some kind of mechanical appliance. The same is true of the steam-power station, in which thousands of horse-power are generated and where thousands of tons of coal must be got from boat or car to the furnaces. When it is realized that the saving in one year, in the handling of 25,000 tons of coal, was $6,000 by the use of proper machinery, it will be seen that the most scientific management does not lie in increasing the capacity of men, but rather in replacing them by mechanical appliances of far greater capacity and efficiency.

Mechanical operations of the simpler kinds, in which the handling of materials may be included, represent principally the performance of work—that is, the lifting or traversing of a mass of material through a given distance—and hence it is entirely practicable to find out how much work is really involved in any particular job of this kind. This renders it possible to compare the efficiency of any one way of doing the work with any other way which may be under consideration, so that something may be learned about their relative value.

The handling of coal, for instance, is a definite matter for any particular establishment; there are a given number of tons, the storage bins are at a known elevation, and the time in which the coal is to be handled may be ascertained. How to do this work by manual labour, by conveyors, by industrial railway, or by some special method has been the study of the engineer for many years. Manual labour, once the only method, has always been inefficient and costly, so that it is not surprising that the early attempts to secure improved shop efficiency began at this point. Various kinds of mechanical appliances followed, until, at the present time, the use of conveyors, of the type best adapted to the locality, has practically superseded human muscle almost entirely.

The question of the best appliance to use, however, is often the critical point in the attainment of the best results for any particular service, and it is in this matter that the skill of the specialist engineer is exercised to the greatest advantage. Engineers who have devoted themselves almost entirely to this department of work have accumulated a stock of experience which the general individual could never expect to obtain, and in this storehouse of precedent there is found, in nearly every instance, the solution of any immediate problem which may appear. It is by the use of such experience that economies similar to those indicated above may be obtained, and that determinate savings may be assured before the apparatus has even been installed.

The great thing is to perform wholly mechanical operations by power-driven machinery, under the advice of specialists, and avoid the use of human effort as much as possible, except in matters of direction and control, thus removing the source of much inefficiency and using men's heads rather than their hands.

## Write for Catalogue No. 053

# Hunt NOISELESS GRAVITY Bucket Conveyor

**Combines the following Desirable Features:**

**Rapidity of Handling**

**Low Cost per Ton**

Hunt Noiseless Bucket Conveyor

**Noiseless in Operation**

## Cost for Operation and Maintenance Less than that of Any Other Conveyor

IF you are interested in the economical handling of COAL, ASHES, CEMENT, GRAVEL, SAND, PHOSPHATE ROCK, ETC., our catalogue will demonstrate to you some of the **possibilities** of economy that can be obtained by the use of the Hunt Bucket Conveyor.

A power plant installed our machinery to handle the coal and saved $6,000 in one year.

A coal dealer installed some of our coal handling machinery and reduced the cost of handling his coal from 17½ to 7 cents per ton.

Write us the work you wish to accomplish. Our engineers are ready to study your particular needs and apply the most economical methods.

We send a representative to any part of the country at any time to consult with you when circumstances so justify.

**Elevating and Transporting Machinery**

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### The Roadbed for Power

IT is said that when King George III. visited the works of Boulton & Watt, at Birmingham, he was received by Boulton, Watt's accomplished partner, with the greeting: "We furnish here what all monarchs desire: Power!"

It is true that not only monarchs, but those who make the existence of monarchs possible—the creators of industry—desire power; but power in itself is useless—it must be provided with a highway to the places where it can be utilized before it can be made of real value. However the power is generated, whether from steam, falling water, direct combustion, or what not, there must be coupled to it a transmission system before it can be of any real service.

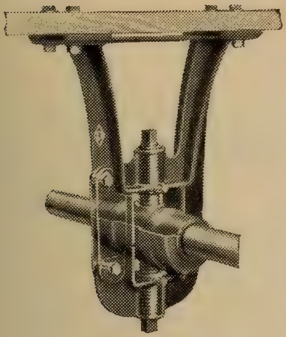
Every manufacturer wishes to see the wheels go around, and from the main wheel upon the prime mover to the thousands of smaller wheels upon the machines which produce the innumerable articles of industry there must be something else going around, something which passes the power on, with a minimum of loss and a maximum of smooth efficiency.

It is along this highway of power transmission, through the silently revolving line shaft, that the power of the engine is passed to the countershafts, belts, pulleys and levers, and kept busily engaged in doing the thousands of things for which power is employed; and in the well-equipped shop every care is taken that the mechanism of power distribution forms in itself a complete machine, delivering power, through its furthest elements, to all parts of the system.

In many respects this roadbed for power, as the line shaft has been aptly termed, bears an analogy to the roadbed of a railway, over which so much of value is transmitted. The ballast on the bed of a railroad may be compared to the balance of the rotating members upon a line shaft; every pulley should be in perfect balance, and, so far as possible, the pull of belts in opposite directions be equalized. Not only as regards balance, but also in connection with support and alignment, may the line shaft be compared to the railroad line. It must be firmly supported, and thus the hangers and bearings come into play, and its alignment must be correct and self-correcting, otherwise harmful resistances will multiply rapidly and efficiency fall off accordingly. It should never be forgotten that the final efficiency of any system, such as that of a line shaft and distribution, consists of the continued product of the several detailed efficiencies, so that any small falling-off in the various elements will produce a much greater influence upon the whole. This means that the closest vigilance is necessary upon all details—watchfulness in the shop, in the erection, and in the continual operation. It does not mean, however, that the transmission should be a continual source of anxiety and trouble to the superintendent of motive power, for if the mechanism has been properly designed and erected it will take care of all these questions automatically.

If the hangers are of the real ball-and-socket construction they will place the bearings themself in parallel with the shaft at all times; if the adjustments may be made in all directions, the shafting can be placed in perfect alignment and kept there; while if the various portions are provided with independent friction-clutch connections, there is every opportunity given for control over the whole system or any of its parts.

Efficiency in manufacture means efficiency in operation, but there is yet a further kind of efficiency—that completeness which is always ready for any emergency. When it is understood that every detail of a power transmission system is kept in stock, it will be realized that there is an efficiency of the highest character, an efficiency which permits a minimum of loss in time of accident, of change, or of extension.



**Ball and Socket Drop Hanger**

# The *Right* Roadbed for Power

DODGE

WHAT **ballast** is to a railway roadbed, **balance** is to the power-roadbed of a mill or factory.

It must be **true.** There must be a proper **alignment** of **shafting.**

And that is a matter of hangers and bearings.

Here, as in meeting every other power Transmission required, the Dodge Idea stands for **SPECIAL** efficiency and economy.

DODGE

## Ball and Socket Shaft Hangers

—with self-lubricating bearings—accomplish **surely** and **economically** what many factory owners seek to bring about by the expensive installation of electric motors.

Dodge Hangers reduce bearing-friction to a minimum.

This is the result of a true ball and socket connection between the bearing and the frame, and a special four-way adjustment that is mechanically right.

Dodge Post and Drop Shaft Hangers offer four types of self-oiling bearings bored and **reamed** to size—insuring a smooth, cool, perfectly-lubricated line of shafting.

Their pleasing design, proper weight-distribution and finish appeal at once to the mechanical eye. Their time- and labor-saving features in erection and alignment and low cost of upkeep figure greatly in the reduction of factory cost.

This is the day of shop standards. The Dodge Idea co-ordinates all transmission appliances as parts of **one** power-distributing machine — interchangeable where possible—with friction clutches to control departments independently.

This improves on the efficiency—and saves the **cost**—of individual motors. There is always a Dodge dealer within hurry call—who can supply you without delay or tie-up.

Shall we send you our special literature telling more about Dodge Hangers and Bearings? Write for it.

## Dodge Manufacturing Company

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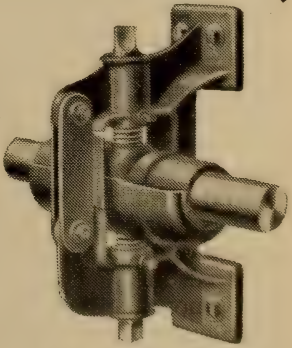
**Minneapolis:** 202-204 3d St., S.
**Pittsburgh:** 337 Second Ave.
**St. Louis:** 507 N. Main St.



**Ball and Socket Post Hanger**

## The Wasteful Story of Coal

IT is a very modern story throughout. Not so very long ago was the first finding of the coal. Then it was to be discovered that coal would burn, and all could sit or stand around and enjoy the warmth of it. Then the fire came to be used for roasting and broiling and boiling, and the boiling brought steam and the steam engine, and through the succeeding developments, which still crowd so closely upon each other, coal has become our chief source of light, as well as of heat and of power, for all manufacturing operations and for transportation upon the land and on the sea. From the coal, as it lies inert in its native bed, to the output of the great power houses and the speeding of the ocean racers, is a long string of conveniences and of methods, which we know to be still crude and wasteful, but which our best investigators and inventors are constantly striving to simplify and to render more economical and efficient.

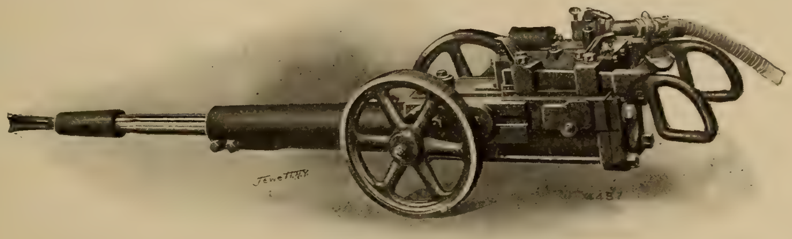
Most gratifying—though still not at all satisfying—results have been attained in the line of coal saving at the hither end of its employment, as is evidenced in the fourfold reduction which, in half a century, has been effected in the fuel cost per horsepower of, say, the Atlantic liners; but it is quite astonishing to realize how little has been done, comparatively, in the line of saving at the mine itself. The ultimate cost of the coal is, of course, the labour cost of getting and handling and transporting it, and the saving of coal anywhere along the line of activities involved in its employment, of course, represents a commensurate saving in the labour cost of the coal; but it would seem that the first place of all to begin the labour saving should be where the coal is first attacked and secured, and yet coal mining machines are among the most recent of our inventions practically developed and employed. Machinery and applied mechanical power save human labour everywhere, and in coal mining it would mean a considerable reduction in the number of human lives exposed to the unusual risks of a most dangerous line of employment. It is estimated that one coal machine with three attendants will do as much work as twenty men working entirely by hand, and yet as recently as 1906, in the United States, only 35.1 per cent. of the coal output was machine mined, and in Great Britain only 4 per cent.

The advantage which the machines give is shown in all the comparisons between the United States and Great Britain in recent years, these figures being generally available only a year or two after date. In 1908, in the United States, 690,438 persons employed produced 126,562,000 more tons of coal than were produced by 966,264 persons employed in the mines of Great Britain. The total of American operators with fewer men produce annually 60 per cent. more coal than is mined in Great Britain. In 1908 the production of coal per person employed was 538 tons in the United States and 271 tons in Great Britain, the average for all civilized countries being 294 tons, very few coal machines being used except by the nations mentioned.

Of the machines employed, there are a number of different types, and both electricity and air are employed to drive them. In the Newcastle district of England in 1909 there were 45 electric machines and 178 air-driven. Of all the machines of all types in use in the United States, about 60 per cent. are pick or puncher machines.

It remains a wonder that machinery has not done more to lighten, or at least to make more individually productive, the labour of the man down in the dark who gets out the coal for us. Every impulse of humanity, as well as all pecuniary considerations, urges the employment of machinery wherever possible, and especially the coal punchers, which are leading the attack.

# "NEW INGERSOLL" COAL CUTTERS



This is perhaps the distinguishing feature of "New Ingersoll" Coal Punchers—"they stay on the job."

And, after all, that is one of the best recommendations a puncher can have. For a machine laid up for repairs not only means idle investment and repair cost, but it means a loss of tonnage output as well.

You have to admit this. And the moment you do so, you have acknowledged the chief reason for adopting the "New Ingersoll."

But there are other reasons, too—low air consumption; ease of operation; popularity among the miners; large capacity, meaning more money for mine and miner.

It is simply good business—good management—to standardize your mine on "New Ingersoll" Punchers.

**COMPRESSORS** **PNEUMATIC TOOLS** **AIR HOISTS**

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## Right Speeds for Cutting Metals

IN the general effort which is being made in all departments of industry to secure maximum efficiency, and thus effect the economies so necessary to profitable operation, it is being understood that attention must be given to the working of the tools as well as the men.

One of the great elements in the increase of output in cutting tools has been the introduction of high-speed steel, but there is for nearly every job a speed which is the correct speed for high output and above or below which the efficiency falls off. This has been realized long ago for rotating work, and every lathe is provided with many speed changes, these being not only for different materials, but also, and, indeed, primarily, because of the varying diameters of work and consequent variations in surface speed.

In the case of the planing machine it is most desirable that the highest possible efficiency be obtained, since such machines represent considerable investment and are usually employed upon large and important machine parts. Quick-return movements have been used, in order that the idle stroke shall be as brief as possible, and now the introduction of the independent electric motor drive is making it possible to provide a very wide range of speeds in either direction at any time.

There are a number of important elements in economical operation permitted by this substitution of the electric motor for the direct mechanical connection from the motive power to the platen. Thus, the reversal of movement is obtained directly in the motor, eliminating the use of shifting belts, clutches, or gear boxes, and with these parts there is removed much loss, noise and wear.

The present interest in the protection of employees from accidents is leading both manufacturers and designers of machine tools to endeavour, as much as possible, to avoid exposed gears and other parts in which the operators may become entangled. The substitution of the motor for the mechanical transmission meets this requirement very fully and removes a number of points of danger.

In the electric drive the amount of power delivered to the table of the planing machine is directly proportional to the work to be done, and the promptness of control and the capacity for overload are dependent upon the design of the motor. Since it is possible so to design the motor as to act as a generator at the instant of reversal, and to short circuit, through a resistance, the current thus produced, a powerful braking action is produced until the speed is reduced to the point where the line current may be reversed, and, with it, the movement of the table. Such an arrangement is prompt and practically positive, permitting quick reversal, eliminating slippage between the motor and table, and giving marked accuracy of stroke.

Undoubtedly, a most important feature in the use of the direct electric drive for planing machines lies in the large number of speed changes possible, and the complete control which is thus obtainable over the character and speed of the work produced forms a valuable element in the question of manufacturing efficiency. By keeping a close record upon the costs of different machining operations it is often possible to decide which method of manufacture may be conducted to the greatest advantage, and thus the entire method of production may be planned in the light of the information thus obtained.

The fundamental principles involved in the cutting of metals thus include, not only the proper tool steel or the correct instruction of the workman, important as these are, but the proper machine tools themselves, with ample power and rigidity, and opportunity for readily attaining the *right* cutting speed.

# PLANER ECONOMY

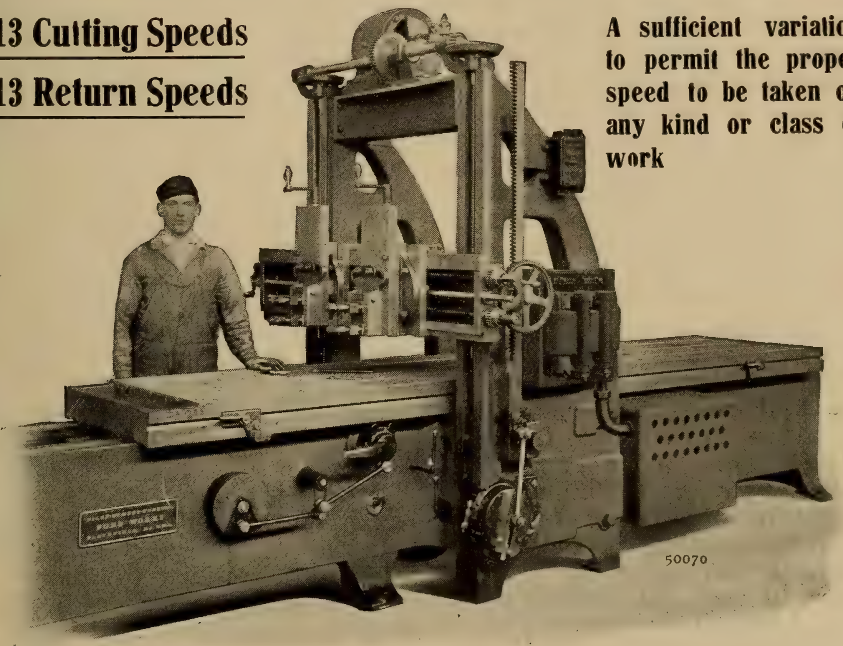
## First Essential Is Variable Speed

POND REVERSING MOTOR PLANER
with Pond Patent Control has

**13 Cutting Speeds**

**13 Return Speeds**

**A sufficient variation to permit the proper speed to be taken on any kind or class of work**



**Pond 36-Inch Reversing Motor Planer**

AS the Pond Planer is driven direct by one reversing motor, the efficiency due to speed variation is further increased by the entire elimination of all belts, gear boxes and clutches.

**Speed changes** may be made at any part of stroke—in an instant—and reversing is so positive and accurate that a stroke of 4½ inches can be readily taken on a 96-inch Planer.

The design and construction of the Pond Planer is accurate, rigid and well proportioned; representing over thirty years' experience, in which every detail has been carefully worked out to the best advantage.

**Write for Four Page Folder, "Pond Planer."**

**NILES-BEMENT-POND CO.**

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### Working with Brains

THERE is a well-known story of Sir Joshua Reynolds that, when asked with what medium he mixed his colours to obtain the brilliant results shown in his paintings, he answered: "With brains!"

A similar method may well be followed in other departments of work besides that of painting pictures, and the industrial arts are rapidly becoming dependent upon the brains of the operatives, as well as their hands. Thus, the introduction of a material new to the arts, such as vanadium, in the production of improved steels, means something more than that a little of this valuable element shall be added to the steel. It means that the vanadium alloy employed should be of a definite composition and character, that it should be added in the proper quantity, and that the proper heat treatment should accompany its use; in short, that it should be mixed with brains. This does not involve any great difficulty, since it is entirely practicable to obtain such ferro-vanadium as will permit the founder and steel maker to know what he is about and to avoid working in the dark; but it does mean that the addition of an indeterminate amount of vanadium, or of any other substance, can give only indeterminate results and lead only to uncertainty.

It is one of the characteristic features of modern scientific methods of manufacture, as compared with the earlier and less precise ways of the workshop, that the workman has been found entirely capable of conducting metallurgical and similar operations in the course of his daily routine with the same accuracy as the chemist in the laboratory. This has been effected by that most essential element in scientific work, the proper co-ordination of methods and operations, so that no man works wholly for himself, but forms a part of a "team," in the same sense as has been found so essential in sports and games in which every man realizes a personal interest in the final success.

If, for example, the foundryman realizes that the influence of such a substance as vanadium, for instance, is so far-reaching that a small variation from the proper proportion will make a wide variation in the effect, he will know that he is dependent upon the man who provides him with the ferro-vanadium which he adds as fully as he is dependent upon the amount which he uses; he cannot get uniform results with non-uniform materials under the conditions of his work. When, however, the foundryman and the producer of the ferro-alloy know each what the other is endeavouring to accomplish, and realizes that each can depend upon the work of the other, all uncertainty as to the final product disappears, and the work in the foundry becomes as truly scientific as that done in the chemical laboratory.

The interesting part of this lies in the fact that the foundryman does not have to become a chemist, and that he does not have to do anything which requires him to change his own effective methods of work in making castings. All that he has to do is to let his work be co-ordinated with that of the manufacturing metallurgist, who himself is utilizing the work of the technical chemist. Instead of working at cross-purposes, these several skilled individuals are working together.

Such methods constitute the real "working with brains" which has become so essential to success in modern times, a method of working which gives to each member of the team the concerted efforts of all the others without requiring any one of them to work any harder or in any very different manner than that to which he has been accustomed. It is the true scientific system which is making things possible which were formerly out of the question, and is bringing the latest results of science directly into industrial activity.

# TO THE USERS OF VANADIUM STEEL

Vanadium as a commercial metal is but a few years old, but in these few years it has revolutionized the possibilities of steel along many lines. The time has been too short, however, to enable all makers and all users of Vanadium steel to arrive at uniform results; differences in the process of manufacture and variations in the methods of heat treatment have produced a diversity of results. Another cause for this diversity has been the opinion that Vanadium acts simply as a scavenger, and that steel in which no Vanadium is found on analysis may have been purified by just enough Vanadium to remove oxides and nitrides.

As the largest manufacturers of Vanadium Alloys in the world, and in possession of carefully verified data on all points concerning the proper way to make Vanadium Alloys, the correct processes of adding them to metals, and the methods of subsequent heat treatment, we feel obliged to call the attention of users of Vanadium Alloys and Vanadized metals to these important points:

1. Alloys of Vanadium must be very carefully made in order to insure freedom from harmful ingredients and to secure a suitable melting point. All products of the American Vanadium Company are rigorously controlled during their manufacture; they are guaranteed correct in analysis and free from impurities known to be injurious in the metal for which they are designed.

2. Metals that are sold as Vanadized metals *must contain Vanadium on analysis*, otherwise the advantages contributed by residual Vanadium cannot be expected.

3. Vanadium metals respond readily to heat treatment. Properly made and properly heat treated, Vanadium Steels in their various types surpass every other known steel for similar purposes.

4. While the methods of adding Vanadium to the various metals and combinations of metals are simple and easily followed, the user must realize that these methods must be exactly observed, and that a departure from the rules determined scientifically will necessarily produce wide variations in the properties of the finished product.

5. If you fail to get superior results from metals supposed to contain Vanadium, send us small samples for chemical analysis and physical examination. Complete reports will be made free with full instructions for heat treatment. State where the material was purchased, how it was treated, where it was to be used and any other essential details to enable us to communicate with you fully.

## American Vanadium Company

MINERS OF VANADIUM ORES
LARGEST PRODUCERS OF VANADIUM ALLOYS IN THE WORLD

**335 Frick Building, PITTSBURGH, PA.**

### Leaders in Progress

IT is probable that men will always be divided into two classes—those who lead in the progress of the world and those who only blindly follow, by imitating what others have had the wisdom to do before them. Decisions have to be made upon judgment and foresight, and, while anyone may imitate and copy, the man of progress will leave the others "sweating and stealing, a year and a half behind."

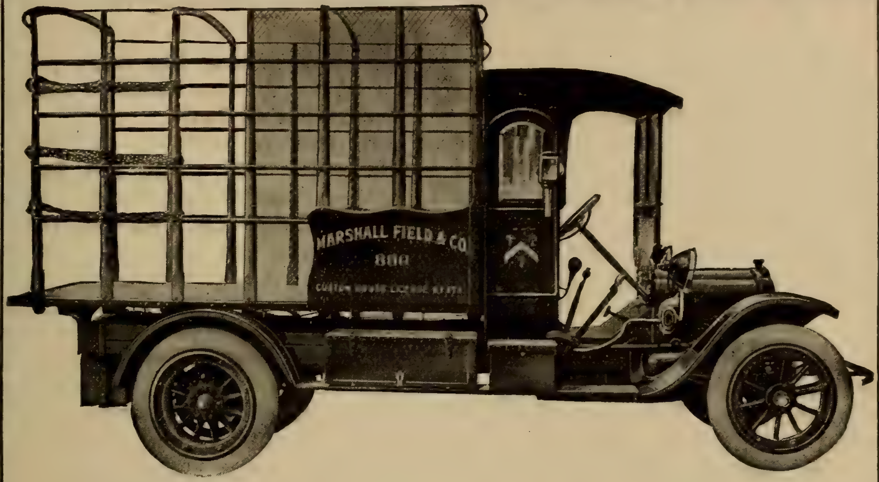
The motor truck situation seems to have reached a point where just such decisions concerning its use may indicate who understand how to grasp an opportunity and who are waiting to play the part of tardy followers. The young and enterprising establishment is set up in the midst of older and more conservative neighbours, and, by its prompt adoption of modern methods, it acquires trade which the older houses had thought was so securely their own that they neglected the obvious competition which the later methods made possible. Besides thus using such improved ideas as swift, prompt, mechanical delivery of goods to customers, the leader in progress does so at the increased economy which the motor truck has demonstrated follows the substitution of the machine for the horse, and thus proves again that the best way is often the cheapest, and effects a gain at both ends.

One of the principal elements in that conservatism which fails to recognize the advantage in being a leader instead of a follower should more properly be called timidity, rather than real conservatism. The horse has always been used to haul merchandise through the streets, and although he has been almost wholly superseded on the highway and replaced by the locomotive for the long hauls, we have become accustomed to that; and, besides, the operation of the railway is in other hands, while the installation of the motor truck means something different right in our own establishment, and we are afraid that it might, somehow, make trouble, even if it did turn out to be an improvement in the long run. So we let our enterprising neighbour get ahead of us, just because we are rather afraid of the change, and we do this until others have passed us in the race, and we have to wake up, and also try to catch up.

It is true that some of the early machines produced for hauling and for delivery service were not well adapted to the work, and failed to give satisfaction; but that period of experiment is now past, and the motor delivery wagon and the heavier machine for larger burdens are both produced in such perfected form as to leave no doubt in the mind of the progressive merchant and manufacturer as to their superiority over the older horse-drawn vehicles, both in efficiency and in commercial economy.

It is apart from the immediate questions of operative cost, however, that the advantage of the motor delivery wagon may well be considered, and the point already brought out above—the leading position acquired by the establishment which uses the latest and most effective appliances in its relations with the public—is one which should be appreciated. There is a social distinction attached to the handsome and speedy motor delivery wagon of the merchant quite comparable with that which exists with the brilliant automobile of the customer, and the establishment which uses the former may be depended upon to secure the custom of the latter. The leaders will continue to lead, and it is only by keeping up with the march of progress that the foremost places in the procession can be maintained.

Real conservatism is something far broader and deeper than a mere stolid adherence to methods which are already becoming outworn and unsuited for forward movement, and it is the standard of real progress which makes for real success in the older as well as the newer establishments.



## The Motor Truck is Your Opportunity

There is a "flood tide in the affairs of men"—there always comes a time in the conduct of every business when a decision for or against new methods determine whether it shall be a leader in its line or the reverse. The Commercial Vehicle is one of the modern improvements—one of the new methods that must solve the cartage problem. We cannot shift the responsibility.

**White Trucks Serve** Securing and keeping trade is growing more and more a matter of service, whether in retail or wholesale lines. In this realm of service nothing is more potent in securing results than the motor truck. The truck is an untiring, reliable steel-and-iron servant of all departments—a machine to take the place of animal flesh and blood.

**White Trucks Save** Through the service they perform, such as increasing the number of trips per day, or the breadth of territory covered, or by long, continuous, daily service, motor trucks, either directly or indirectly, are big economical factors in every business. Each truck or delivery wagon replaces from four to eight horses, in accordance with the capacity of the truck.

## White Trucks Superbly Built

White trucks secure results because they are superbly built—because the engine was designed for a truck and has the simplicity which means good mechanical principles, accessibility of every part, and that it is easily driven. The materials are the best that modern science has evolved, including the highest types of steel alloys and the heat-treatment of them. The White factory not only has the mechanical equipment and skilled workmen, but fifty years of manufacturing experience and the financial responsibility.

Let us submit a solution of your delivery problem—send our latest truck catalogue—list of owners in your territory and the testimonials of some of the largest users in the world.

**The White Company**

832 EAST 79th STREET, CLEVELAND

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### Letting in the Daylight

THERE are all kinds of tools with which the industrial operatives of to-day do their work, and the best of them are none too good for the kind of work which is demanded of the modern skilled mechanic. Among these implements of industry there is probably nothing of more importance than good, clear daylight. The old-time shop was noted for its dirty windows and general smudgy atmosphere, permitting things to be seen only with marked effort, while the foundry was usually a place where men groped their way amid a dusky surrounding of smoke and haze. This state of affairs seemed to be taken for granted, and the idea that it was necessary to have abundant sash opening, with clean, clear glass, did not appear to be considered at all as an essential to maximum efficiency in the shop.

During the past few years, however, a great light seems to have dawned upon the works manager, and instead of paying out money for electric lighting it has been found entirely practicable to let in the brilliancy of outdoor sunlight, together with ample ventilation, and the result has been amply repaid by the improvement in the men and their output.

With the old-fashioned wooden sash the amount of opening which could be safely glazed was limited; there was the danger from wind storms and the probabilities of leakage to be considered. These difficulties are met to-day by the use of windows fitted with frames of solid steel bars both light in appearance and, at the same time, possessing ample rigidity and sufficient stiffness to avoid the necessity for any obstructing frames or heavy dividing mullions.

Artificial light costs money, while daylight is free; and the light from the sun is far purer and whiter than can be made in any artificial manner, besides being a germicide of widely extending action.

The extent to which these facts are being appreciated will be seen by observing some of the more recently erected factories and workshops, and noting the large proportion of the surface which is open for the entrance of light.

Of course, such a material as rolled-steel sash could not be produced in single elements by the ordinary builder, and hence its use did not become general until it was placed on the market as a regular standardized article of manufacture. During the past few years, however, it has been manufactured from specially rolled sections, in sizes and forms adapted for factories, garages, lifts, power houses and the like.

By adopting a system of standard units, it is possible to use multiples to give any desired width for the height selected, while the employment of hinged ventilators provides the proportion of air circulation required.

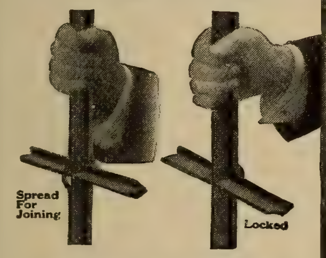
The production of standard steel window frames, of ample strength and rigidity, enables the builder of manufacturing establishments to provide all the lighting surface in the walls which may be required, regardless of the amount of opening in the walls which this may involve. It is not necessary to introduce stiffening members, since the windows themselves are amply strong, so that the construction becomes practically a portion of the building itself, making a complete and serviceable whole.

It is now generally recognized that an important factor in efficient production is the health and comfort of the workmen, and that buildings in which the employees have ample light and pure air conduce to general high efficiency in the output of the men thus cared for. Especially when products demanding accuracy and precision are manufactured does the provision of ample illumination conduce to the effectiveness of the work itself, while the general cleanliness and healthfulness which accompany ample illumination amply repay the moderate first cost involved.

Factory of Hudson Motor Company, Detroit, Mich.

THE Permanence and Pre-eminence of Detroit-Fenestra are assured by the remarkable strain-resisting qualities of the patented Fenestra Joint, where strength is gained at point of intersection.

**The "Fenestra" Joint**



**Practically No Metal Lost**

## Detroit-Fenestra Solid Steel Windows

*"Daylight for Factories"*

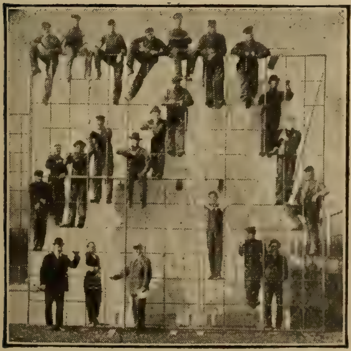
answer the cry of the worker for light and air; they lighten labor, and every employer realizes cash returns from a healthy, contented, competent force. Detroit-Fenestra windows are fireproof, and will stand the test of weather and of time—minus the usual upkeep expense.

Let our engineers solve your ventilation problem.

Write for Catalog X.

**DETROIT STEEL PRODUCTS CO.**

**Dept. 26, Detroit, Mich.**



# FINANCIAL NOTES

$ $ **A department of information on industrial and other securities of value to investors and men of affairs.** $ $

OF THE
## INDUSTRIAL WORLD

**SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible, the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.**

**CHARLES EASTON, Financial Editor.**

### The Situation

Developments in the business world the past few weeks have been coming rapidly enough to encourage the belief that a turn for the better is not a remote possibility. It is believed that the rendering of the Supreme Court decision in the Standard Oil and American Tobacco cases and the cutting of prices for steel products foreshadow an improvement in the entire situation. Just at present the industries are very quiet. Reduction in steel prices has had the effect of checking rather than encouraging extensive buyers. Consumers are holding off in the hope that still further reductions may be made. Railways and industrial corporations are now beginning to show the results of greater operating economies. Net earnings are making a better showing, by reason of reduced expenses. Better results are confidently expected by the best informed, and it is to the credit of the managements that they are seeking to effect the desired ends through efficiency of operation. With assurance of splendid crops and the elimination of fear and forebodings as to court decisions, there is absolutely no reason why at least a normal degree of activity should not be experienced in the industrial world.

The independent producers of copper are still in control of the market, and are holding off for better prices.

The investing public manifest a constantly increasing inclination to buy bonds for investment rather than stocks for speculation.

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Among the recent heavy bond transactions were the following: $16,000,000 Chesapeake & Ohio 4½ per cent. notes; $10,000,000 Louisville & Nashville 4 per cent. bonds; $7,500,000 Chicago & Northwestern general mortgage 4s.

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The Lake Erie & Pittsburg Railroad has filed a first mortgage of $15,000,000, to run fifty years, in favor of the Guarantee Trust Company, of New York, as trustee. This is the final step towards the financing of the road. Bonds will be sold from this issue to the extent of about

# Profitable Publicity Assured

## Second Series. No. 2.

**First Series Containing Letters from the following firms Free on Request**
**Send for it and read what they say:**

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No. 7. The C. W. Hunt Co.
No. 8. The Jos. Dixon Crucible Co.
No. 9. The Jeffrey Mfg. Co.
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No. 11. The Riggs House
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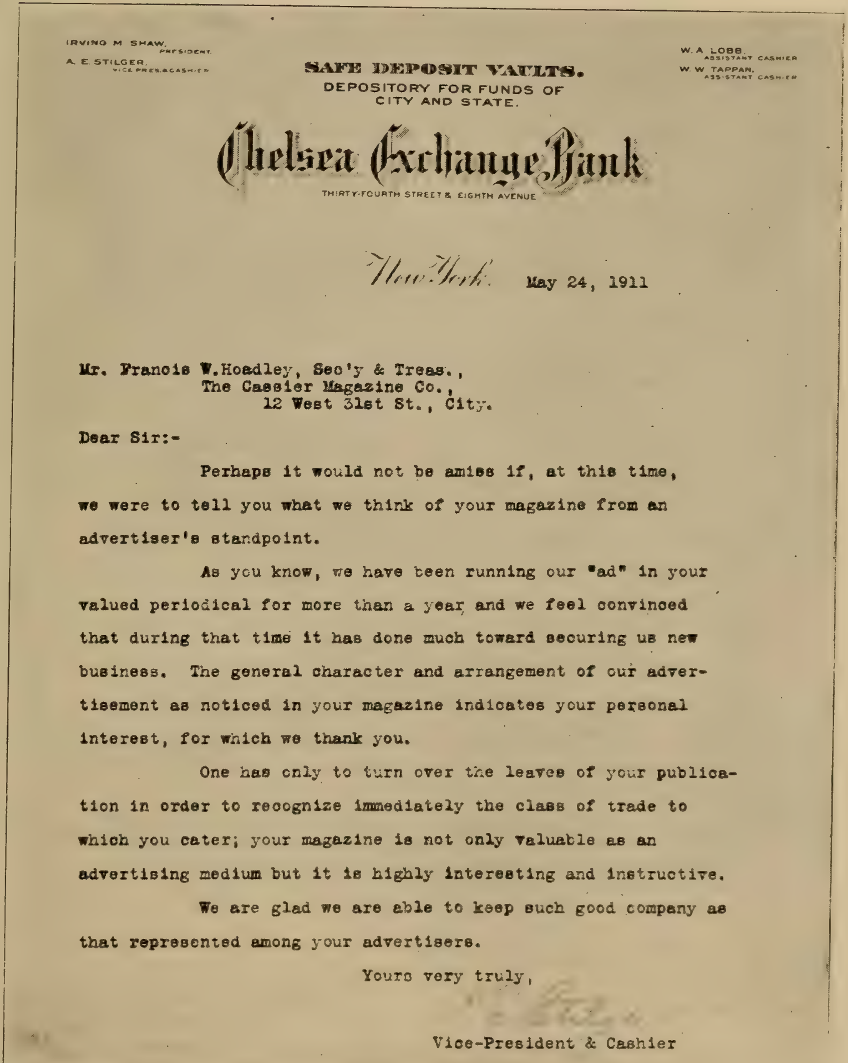

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W. A. LOBB,
ASSISTANT CASHIER
W. W. TAPPAN,
ASSISTANT CASHIER

New York. May 24, 1911

Mr. Francis W. Hoadley, Sec'y & Treas.,
The Cassier Magazine Co.,
12 West 31st St., City.

Dear Sir:-

Perhaps it would not be amiss if, at this time, we were to tell you what we think of your magazine from an advertiser's standpoint.

As you know, we have been running our "ad" in your valued periodical for more than a year, and we feel convinced that during that time it has done much toward securing us new business. The general character and arrangement of our advertisement as noticed in your magazine indicates your personal interest, for which we thank you.

One has only to turn over the leaves of your publication in order to recognize immediately the class of trade to which you cater; your magazine is not only valuable as an advertising medium but it is highly interesting and instructive.

We are glad we are able to keep such good company as that represented among your advertisers.

Yours very truly,

Vice-President & Cashier

**"Our advertisement in your magazine has done much toward securing us new business."** A. E. STILGER, Vice-Pres. and Cashier,
*Chelsea Exchange Bank, New York*

**How to Finance a Suburban Home**

We will finance a home for you according to your own plan on attractive building site within a few moments' walk of Tuckahoe and Bronxville stations, the highest and most picturesque section of Westchester County, New York, 30 minutes from Grand Central Station, New York, N. Y.

*Write for particulars*

**Debenture Corporation of New York**
**334 Fifth Avenue, New York**

The Delaware and Hudson Company

NOTICE TO MANUFACTURERS

This railroad extends from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines ; provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, connecting the river with Lake Champlain, now being built by the state. An establishment located in this territory receives the benefit of cheap fuel, electric power and low freight rates.
Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

IRA H. SHOEMAKER
Industrial Agent ALBANY, N. Y.

$7,500,000 to reimburse the Lake Shore and Pennsylvania for the amount so far expended on the line.

The president of the Amalgamated Copper Company, in the report for the year ending April 30, states that the capacity and the value of the plants and equipment are greater than at any time in the history of the company. Notwithstanding the $30,000,000 that has been written off in depreciation, the report shows net earnings of more than $6,000,000, with a surplus and reserve of $21,500,000.

The new State of Oklahoma has shown a remarkable increase in capital invested in manufacturing. The amounts increased from $16,124,000 in 1904 to $38,873,000 in 1909. The cost of material used increased from $16,000,000 to $34,000,000, and the value of products from $24,000,000 to $54,0000,000. The average number of wage-earners increased 141 per cent., and the number of establishments 106 per cent.

The sales of farm machinery by the International Harvester Trust in 1910 reached $101,000,000, an increase of $14,500,000 over 1909 and $28,000,000 over 1908. We have seen no mention of the profits realized from this enormous business. The total assets of the company aggregate $195,000,000.

Another "Carnegie boy" has been moved up a peg. This time it is John Reis. He has been made vice-president of the United States Steel Corporation. An authentic and well-written story of the rise to wealth and prominence of the men who have figured most prominently in this great corporation would make interesting reading.

The United States Motor Company, one of the two biggest automobile manufacturing companies in the United States, has just sold to a Wall Street syndicate 6,000,000 6 per cent. five-year notes. The price is not stated, but conjecture places the underwriting at 88. The outside public will be let in several points higher. A considerable amount of the company's maturing paper will be taken up and the balance of the money will be used to augment the working capital and extend the business.

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The Baltimore & Ohio Railroad is slowly emerging from its trouble of a year ago, when the company was in need of so much that was necessary to add to its operating efficiency. President Williard and his assistants are to be congratulated on their work of rehabilitation. The margin of earning applicable to the 6 per cent dividends is now such that important interests in the board of directors have given assurance that the dividends will be maintained.

It is reported that the current fiscal year, which will end June 30, will show an increase in profits of the International Paper Company. Last year 4.54 per cent. was earned on the preferred stock, while this year about 6 per cent. is expected to be earned.

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### Increased Market for Drainage Fittings

In order to meet the great demand on them for drainage fittings, the McNab & Harlin Manufacturing Company, whose works are at Paterson, N. J., have greatly increased the machinery and pattern equipment of their plant, so that orders can be promptly executed. They have also remodeled and enlarged their galvanizing plant to sufficient capacity to take care of the increased production.

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### Alaska's Twenty Million—The Territory's Output of Precious Metals Increased in 1909 Over a Million Dollars

In 1880 gold was produced in Alaska to the value of $20,000. In 1909 the amount mined was valued at more than $20,000,000. In 1888 silver was first produced in Alaska to the value of $2,181; in 1909 the value was $76,934. In 1902 copper was first produced to the value of $41,400; in 1909 its value reached $536,211. These and other statistics

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**6% For Your Savings**

Our plan in issuing 6% Gold Bonds, that are secured by New York Real Estate, enables investors of moderate means, or those who desire to start a savings account, to secure a gilt-edged investment.

The principal is absolutely safe and the interest certain to be paid as it becomes due.

The bonds are sold at par, bear 6% interest, which is payable quarterly, and mature in ten years.

You can purchase them for all cash or take twenty months in which to pay for them. In either case your investment earns the 6% on whatever amount you have paid in.

They are issued in denominations of $100, $500, and $1,000.

Let us mail complete details to you without obligation on your part. Write

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**334 Fifth Avenue, New York**

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**Middle West Engineering Plants**

Best locations for Coal and Iron supplies and for markets in many lines.

Rail and Water Transportation. Maps, plans, photographs and data regarding the power and machinery equipment may be seen in my office.

**Lumber Mill and Timber Tract**

Both the buildings and the equipment are new. The latter was selected for the purpose of utilizing everything of value that enters the mill. The timber tract includes nearly 1,200 acres with other timber available near the mill. The entire property can be purchased for less than two-thirds of the original investment.

***If you wish to buy or sell Industrial Property, Consult***

**H. C. HORTON**
**Business Broker**
**50 Pine St., New York**

of production are shown by Alfred H. Brooks, of the United States Geological Survey, in "Gold, Silver, Copper, Lead and Zinc in the Western States and Territories," published as a separate chapter of the volume, "Mineral Resources of the United States in 1909."

"Placer and lode mining of gold in Alaska in 1909," says Geologist Brooks, "showed marked progress over that in 1908, both in the amount of actual gold production and in the advances made in preparation for more extensive operations.

"The copper output was less than in 1908, chiefly because the low price of this metal did not encourage mining; but nevertheless much was accomplished toward the preparation for a large future increase in copper 1909 are but slightly different from production." These final figures for the preliminary estimates made by Mr. Brooks nearly a year ago.

---

The American Car & Foundry Company surprised the public by its favorable report for the fiscal year ending April 30, 1911, which shows 6 per cent. earned on the $30,000,000 of common stock. This explains the strength the stock has generally shown, even in days of very weak markets.

The American Tobacco Company's stock declined 82 points immediately after the Supreme Court decision was rendered against it. The Wall Street theory of this decline is that some small stockholders very foolishly became frightened. The Tobacco Company is earning at the rate of approximately $50,000,000 a year, which is a most remarkable industrial achievement.

The Pennsylvania Railroad Company paid to families of its employees through its relief department in March $225,000.

Through radical economies, the New York Central made a net showing of more than $1,600,000 in March. The earning this year was nearly twice the amount earned in March, 1910.

The famous Glen Cove plant of the National Starch Company, which had been carried on the books at a valuation of $1,000,000, was recently sold for $50,000.

---

It is authoritatively reported that the Westinghouse Electric Company is making new high records almost every month, in volume of business as well as net profits. While the earnings are exceptionally good, nevertheless the directors appear amply justified in pursuing their policy of further strengthening the company's financial position before common stock dividends are begun. It would seem that the common shareholders could very safely and profitably leave the matter of dividend disbursements to the present managers of the company, who have taken the concern out of receivership and brought it to its present satisfactory position.

---

The Kerr Turbine Company, Wellsville, N. Y., has just been reorganized, and $125,000 new capital has been added. The stock interests of the company are now controlled by F. P. Merrill, of Hornell, N. Y., and P. B. Hanks, of Wellsville, who, as trustees, have directed the affairs of this company for the past two and a half years. Mr. Kerr is no longer with the company, his position as chief engineer now being filled by Mr. J. L. Moore, formerly a designer with the Westinghouse Electric & Manufacturing Company, and later in the engineering department of the Santa Fé Railroad.

The present plant will be materially enlarged, and a new machine shop is already in course of erection.

It is the intention of the new company to incorporate into the Kerr turbine, design changes which are based upon two years' experiments and which will improve the steam economy on all sizes from 15 to 20 per cent.

**Chelsea Exchange Bank**

**34th Street and 8th Avenue**
**NEW YORK, N.Y.**

**Capital - - - $200,000.00**
**Surplus and Undivided Profits $196,000.00**

**Depositary for the State and City of New York**

**Prompt remittances made on all drafts sent us for collection.**

**SAFE DEPOSIT VAULTS**
**Boxes $5.00 per year up**

*We are located just a stone's throw West of the 34th Street entrance of the new Pennsylvania station, making it very convenient for the transaction of your banking business.*

*Your account is solicited.*

**Officers**

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A. E. Stilger, Vice-President and Cashier
Wm. A. Lobb, Assistant Cashier
Wm. W. Tappan, Assistant Cashier

**The...**

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The Magazine of Authority on the Manufacture and Uses of Portland Cement, acknowledged by all cement manufacturers, architects, engineers, contractors and cement products manufacturers.

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Mention this and mail to us at our risk one dollar in cash, money order or stamps for one year's subscript on; we will present you a copy of "A Brief History of Cements," by I. C. Johnson, Gravesend, England, Inventor of Portland Cement.

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The leading journal published in the interests of the cement industry. This magazine is the standard publication in the field, carrying the latest authoritative reports of the progress made in the theory and practise of concrete engineering.

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Southern States last year contributed $557,000,000 of the cash resources of the country in the shape of cotton shipments to Europe.

At St. Petersburg, Russia, is one of the largest rubber factories in the world. Its annual output is 25,000,000 tons.

The reduction of the rate of interest by most of the savings banks is forcing money into building operations and real estate investments. There is a growing demand for real estate bonds. We look upon the better companies issuing 6 per cent. securities against their real estate holdings with favour.

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### Capital Stock of the Milwaukee Refrigerator Transit Company Increased from $150,000 to $400,000.

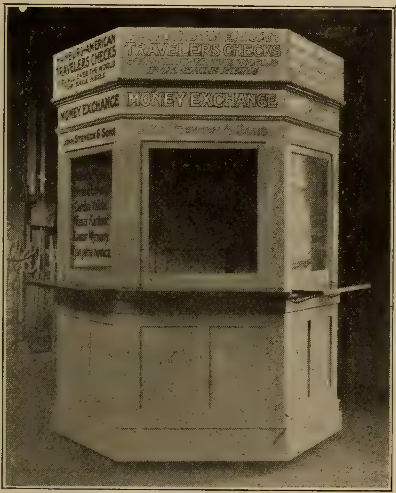
The stockholders of the Milwaukee Refrigerator Transit Company at a recent meeting increased its capital stock by $250,000 and changed its name to the Milwaukee Transit & Car Company. This change in name was for the purpose of absorbing the Milwaukee Car Manufacturing Company, whose plant and properties of all kinds were taken over by the former company in April. All contracts, liabilities, etc., of both the former companies were assumed by the new company. Many improvements are contemplated to the first-class car shop this transaction gives the new company—a shop fully equipped for the building of new cars and the repairing of old ones—but such improvements will in all probability be held up until such time as the situation with the railroads becomes more encouraging. The company will manufacture and repair cars for both its own and other companies. The following equipment has been purchased and is now being installed: One Fay & Egan car tenoning machine, one 250 horse-power Sterling boiler, one 95 horse-power Berlin planer and matcher, one Bentel & Margedant railway cut-off saw, and one Ferguson bolt furnace.

## A Perambulating Bank for Travelers.

### By M. B. Claussen.

A HALF-CENTURY or more ago a leather belt with numerous pockets was the common receptacle for valuables on ocean voyages. The method was picturesque, to say the least. Holdups were common, and the possibilities of loss considerable.

With the growth of travel and the improvement of general conditions, provision was made aboard the ships for safeguarding the passengers. The purser came to carry considerable sums of money. Until recently, however, banking methods on the high seas remained somewhat crude. To the foreigner traveling on an alien ship the inconvenience of exchanging money was, naturally, great.



A PERAMBULATING BANK.

The problem was largely solved by installing up-to-date safe deposit vaults on liners. Safes, completely thief-defying, were equipped with drawers placed at the disposal of travelers. In these might be placed money, jewelry, or valuable papers of any kind, securely locked till the end of the voyage.

Gradually, however, actual money, in large sums, has practically disappeared. To-day the tourist makes use of the convenient travelers' cheques. This does away with the confusion of changing one's money

Cumberland, Md., Jan. 10,-'10

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into the coin of the realm at every port of call. The economy in the cost of exchange is, incidentally, considerable. During the around-the-world voyage of the S.S. *Cleveland,* of the Hamburg-American Line, a most complete test of the travelers' cheques was made possible. At scores of different ports of call on this belt line, and amid every strange people, the tourists found it possible to supply themselves with the foreign currency without the least inconvenience, and, of course, with perfect security.

The difficulties of arranging money matters in the confusion usually found on the docks long remained a bugbear to travelers. Valuable time was lost in the effort to exchange foreign moneys into the current medium. The necessity of paying the duties exacted by the customs officials as quickly as possible served to add to the confusion. It was common for incoming tourists to miss railroad connections while struggling with this problem. The drivers of taxicabs in New York once did a thriving business by advancing the necessary funds and then carrying tourists to the banks for them to arrange their money affairs, charging, of course, a considerable premium for the accommodation.

The newest banking innovation of convenience to travelers is the perambulating bank. A portable office, mounted on wheels, has been installed on the dock of the Hamburg-American Line, at Hoboken. On the arrival of a steamer the portable bank is wheeled to a convenient position at the very foot of the gangway near the custom house officers' desk. The clerical force of the bank is the most polyglot of its kind in the world. Its clerks, collectively, speak a score of languages and dialects, so that the incoming travelers from the four corners of the earth may carry on their conversation as readily as in their home countries. The portable bank, which is conducted in connection with the banking firm of John Steneck & Sons, cashes travelers' cheques, exchanges money, and, in short, carries on a general banking

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business. In a few minutes, without leaving the steamship dock, the tourist can therefore arrange all his money matters and be ready to venture into the city with a clear mind.

The arrival or departure of a steamer brings a rushing business to the perambulating bank. The little exchange is surrounded by a crowd of tourists. In the variety of tongues spoken they even rival the Tower of Babel. Here travelers from foreign countries, however remote, find those who speak their own language perfectly. One of the most serious annoyances of travel—arranging money matters in an alien bank—is done away with.

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### Fighting Friction

LIKE nearly every element which the engineer has to meet in his work, friction is a very good servant, but a very troublesome master. It tries to get the mastery so often that if it is not fought with continual skill and activity it will, sooner or later, get the better of one, and then all kinds of trouble will follow.

Of course, the natural weapon with which to fight the resistance of friction is some kind of a lubricant, and nearly every kind of rubbing combination in machinery has provided for it a suitable lubricant to keep things smooth and free-running. The problem in lubricating the running parts of machinery lies, not so much in finding a proper lubricant, but in getting it in between the rubbing surfaces.

Take the case of a line shaft, for instance! It has to be supported in journal bearings at many points along its length, these bearings carrying, not only the weight of the shaft itself, but also the load of numerous pulleys and the pull of many belts, and one of the questions in the design of these bearings is the provision of such an area of rubbing surfaces that the pressures upon them may not become too great. If, for a moment, any of these rubbing sur-

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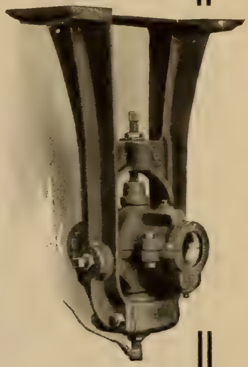
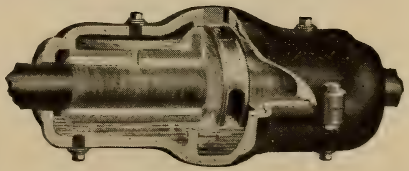


**Hill Drop Hangers**

The bearings have a four point adjustment (see illustration) which allows of a re-alignment of shafting in any direction without moving the hanger frame. Trunnion supports give an automatic ball and socket movement to the bearing

**Will run with minimum friction if you use**



**Hill Collar Oiling Bearings**

Oil is continuously and positively elevated to the top reservoirs by a heavy split collar. From the upper reservoirs oil flows by gravity over the entire bearing surface. Oil Collar also takes the end shaft thrust, thus eliminating all outside collars.

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faces should become dry, the friction will become so great as to cause heating, trouble and delay, and unless immediate relief is afforded the whole line is stopped.

This means that a film of lubricant must be kept in between these heavily-weighted, rapidly-rotating surfaces at all times; not that a flood of oil is to be poured over the outside, but that the right amount of oil shall be insinuated right in between the surfaces where the friction is being produced. It is evident that this is not an easy matter, but it is not an impossible thing to accomplish, provided the correct design of parts is followed and the matter of lubrication is made a part of the actual construction. If a continuous circulation of oil is maintained, by feeding it in at points along the top of the bearing, allowing it to run off from below, and again delivering it at the top, no opportunity is offered for the rubbing surfaces to become dry, and continuous lubrication is maintained. Such a system works all right while the shaft is in motion, but to it must be added such an arrangement of parts as will cause the circulation to be started as promptly as the motion begins; for the friction starts with the first revolution, and will get its resistance at work before the lubricant can slip in to oppose it.

The true method of fighting friction, then, is to provide a system of lubrication which shall be as continuous as the friction itself, which shall extend over the entire area of rubbing surfaces, and which shall start promptly when the friction starts, and not stop until the motion of the shaft itself ceases.

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At a recent meeting of the American Foundrymen's Association a paper was read by Mr. G. L. Norris on "Vanadium in Iron and Steel Castings." Attention was called to the fact that vanadium makes a fine-grain material tough and workable, with the graphite well distributed and specially adapted to cylinder castings and the like.

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# PERSONALS

Mr. Walter S. Bickley was unanimously elected president of the Penn Steel Castings & Machine Company, of Chester, Pa., by the board of directors of that company at their annual meeting May 12, in place of Mr. Mortimer H. Bickley, deceased. President Bickley started in with the Penn Company some years ago and gradually worked through the several departments until he was appointed to the position of superintendent. This position he filled with ability and efficiency, and he secured the confidence and esteem of the stockholders, as was shown by his election as the head of the corporation.

The honorary degree of Doctor of Science was conferred by the University of Pennsylvania, at its recent Commencement, upon Mr. William Lawrence Saunders, president of the Ingersoll-Rand Company.

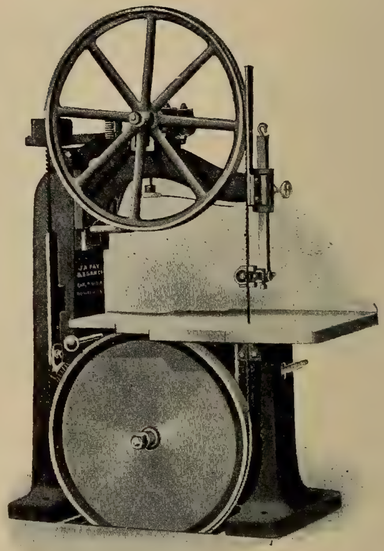
Mr. Saunders has well earned this honor by the brilliant career which has placed him in the front rank of American engineers, and his technical and scientific work in one of the most important departments of engineering is fitly marked by this academic distinction from the university in which he received his professional training.

Mr. J. J. Harvey, who has been for several years connected with the American Locomotive Company, and is an expert in the construction of gasolene engines, has accepted the position of manager of the Powell Marine Engine Corporation, of Brooklyn, N. Y., assuming his new duties in July.

Mr. John F. Wallace was recently elected president of Westinghouse, Church, Kerr & Co.

### A High-Duty Band-Saw

One of the most important tools in any wood-cutting shop is the band-saw. It is in almost constant use, from starting to quitting time. It follows, therefore, that great care is always given to the selection of this tool.



The choice of the expert mechanics, especially those in the railway service, now seems to centre on the Fay & Egan No. 58, with 42-inch wheels, for general and heavy band scroll sawing of all kinds.

The fact that more than two thousand of these saws have been made and sold by the Fay & Egan Company and never a complaint received is certainly a great record, and leads us to illustrate this tool herewith.

The first impression one receives upon looking at this machine is the square form of column, cast in one piece and gradually tapering upward from a broad base. This new form was made necessary by reason of the fact that the old style "goosenect" frames would not stand the terrific speed at which the new patented knife-edge straining device made it possible to run the blade.

In addition to increasing the speed of the blade over 50 per cent., the

Fay & Egan patented knife-edge straining device also made it possible to use the very thinnest blades without danger of cracking. This necessitated the construction of a solid lower wheel to control the light upper one, preventing over-running of the blade and choking in a heavy cut. The increase in quantity and quality of output by reason of the above-mentioned improvements will be obvious to all mechanics.

Information regarding this machine, or of the manufacturers' complete line of band-saws, can be obtained by addressing J. A. Fay & Egan Company, 226-246 W. Front street, Cincinnati, Ohio.

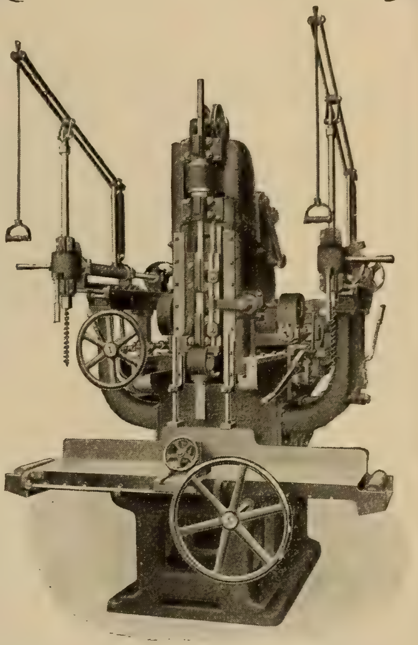
### Proposal to Change the Name of American Institute of Mining Engineers

It has been decided by the council and board of directors of the American Institute of Mining Engineers to recommend a change of its name to "American Institute of Mining and Metallurgy." The idea in making the change is that the name proposed represents more broadly what the organization stands for, the present name being a misnomer to a large extent. This proposal will be submitted for ballot to the entire membership.

### Furnace Stoker Proofs

Under this heading there has been issued by the American Stoker Company, New York, N. Y., a little pamphlet, in which they give a list of some of the well-known firms who have, during the ten years or so, sent them repeat orders. Among the firms so listed are the Cleveland City Forge & Iron Company, thirty-two stokers ordered from 1900 to 1910; American Car & Foundry Company, Detroit, Mich., thirty-two orders since November, 1901; American Bridge Company, Chicago; the Berger Manufacturing Company, Canton, Ohio, and the Youngstown Sheet & Tube Company, Youngstown, Ohio.

*Those Who Know Know*



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## BOOK NOTES

### Vehicles of the Air

The 1911 revised edition of "Vehicles of the Air," by Victor Lougheed, is now ready. Mr. Lougheed's book is, without a doubt, the most comprehensive, practical work on the art of flying that has yet been published in this or foreign countries. The revisions bring the book down to date—May 1, 1911. The tabulated lists of flights, from the earliest to the present time, also the analysis of fatalities, are of much interest. All the drawings of successful machines are drawn to scale, so that anyone mechanically inclined could make his own flying machine. How to design, construct, operate and repair are taken up and treated at length. This book is enjoying a large sale at the present time throughout the English-speaking world, and has attained the distinction of being called "The Aeronaut's Bible." The Reilly & Britton Company, publishers, are to be congratulated on publishing such a complete and up-to-date work. The book contains over 550 pages, 500 subject headings, 200 aeronautical terms defined, 270 illustrations, including 140 half-tone views. The price is $2.50 net; postage 25 cents extra. This book is published by the Reilly & Britton Company, Jackson boulevard and South Wabash avenue, Chicago, Ill., U. S. A., and should be in the library of all those interested directly or indirectly in aerial locomotion.

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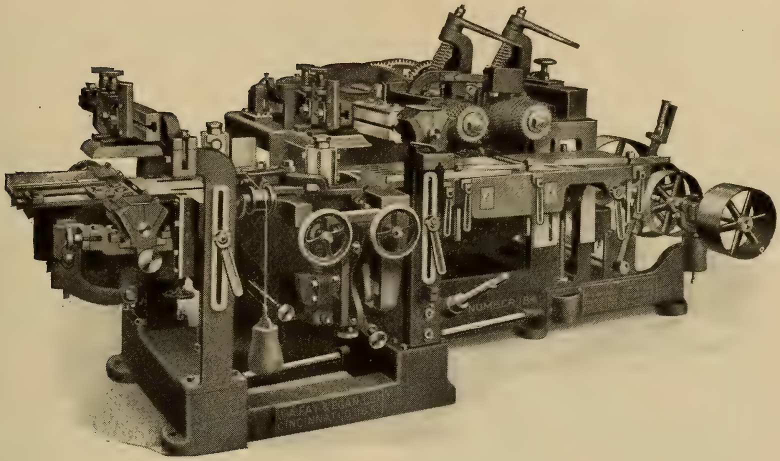
### Magnetic Properties of Heusler Alloys

"Magnetic Properties of Heusler Alloys," by Edward B. Stephenson, has just been issued as Bulletin No. 47 of the Engineering Experiment Station of the University of Illinois.



EXTRA HEAVY FOUR-SIDE MOULDER. THE J. A. FAY & EGAN COMPANY, CINCINNATI.

### A New Moulder

DURING the past year the mechanical engineers of the J. A. Fay & Egan Company have been devoting much time to the improvement of machines for making mouldings, and the result is the introduction of a new model to the trade by the great works at Cincinnati, this machine being an extra heavy four-side moulding machine, to be known as No. 184.

This machine is made with a capacity for material 12 to 14 inches in width. The base, to which special attention is directed, has the sole plate cast in one piece, of extra weight, and extended to provide an outer bearing for the upper head, and to eliminate excessive overhang in the lower head, and the entire construction is most massive. Good belt length is provided, but at the same time the machine is the most compact moulder yet shown.

Another important feature in this machine is the provision of angle clamp boxes, which eliminate occasion for shutting down for babbitting. Attention is also called to the wide open construction, the end platen, pressure bars, and chip breakers all swinging back to give easy access to the heads. The angle and cross adjustments for both side heads are made from the operating side of the machine, a very convenient arrangement.

The gearing is extremely heavy, the lower gears being the full width of the upper ones, and the adjustable post to outside bearing is detachable. The feed rolls have spring pressure, thus eliminating cumbersome weights; and the countershaft is mounted on the machine and is adjustable vertically and laterally. The belts for the upper head have an adjustable idler, and the outer side-head, matcher clip and fence are adjusted laterally as a unit. The lower head has vertical and lateral adjustment; the screws for raising and lowering the bed are mounted on ball bearings, and the feed is powerful and positive.

The general arrangement of this machine is shown in the accompanying illustration, while fuller description and large illustration may be obtained by communicating with the manufacturers, the J. A. Fay & Egan Company, 226-246 West Front street, Cincinnati, Ohio.

## Mechanical Efficiency

THERE has been a good deal of discussion as to the comparative efficiency of men and machines, and much of the modern discussion about increased efficiency has been based upon the possibilities of getting a greater proportion of available work out of men than has hitherto been considered possible. Doubtless it is practicable, by judicious arrangement of tasks and keen supervision, to reduce the amount of labor required to perform the various kinds of work involved in manufacturing operations, but the fact must not be overlooked that a very large proportion of the work which is now being done by human effort ought not to be done by men at all.

It has been said that the so-called modern scientific management tends to make men into machines and to deprive them of any opportunity for the exercise of their judgment or initiative, and if this is true it would seem as if the work they were doing was of a kind which did not require anything but mechanical effort from the workman, the judgment and plan of the work being supplied entirely independently. Under such circumstances there seems to be no reason why such work should be performed by the comparatively inefficient method of muscular effort, since it might be so much better done by inanimate machinery, designed by specialists and supervised by men of moderate strength but trained judgment.

In certain departments of work this is certainly true. Formerly, the shovel was considered as the symbol of honest and dignified labor, either in the operations of agriculture or in the moving of bulk material, such as coal, gravel, sand, ashes, or other similar substances. The man who had strength and opportunity was supposed to be able to do such work all right, and not have to use his brains at all. Such men may still do such work, but they cannot begin to do it with the same efficiency as can be done by properly-designed machinery, and it has been amply demonstrated that the actual cost of shoveling coal, for example, by hand, is more than double what it is when performed by modern coal-handling machinery.

To-day, men are employed to do one of two different kinds of work —either to use their skill in performing operations which require the trained hand directed by the intelligent brain or to piece out the disconnected ends of mechanical work which should have been so connected as to require no human intervention.

Thus, to illustrate the latter case, if a delivery of coal from a train or barge is shoveled out into a heap, and then again shoveled into boiler furnaces, we see that the manual end of it is doing what would have been far better performed if the coal had been directly conveyed mechanically into overhead storage bins and allowed to pass by gravity through chutes to mechanical stokers. The men were machines, doing machine work which could be far more effectively performed wholly by machinery.

Even in many machining operations the use of automatic tools has been found more desirable than the service of independent mechanics, and in nearly every department of work it will be found that maximum efficiency is obtained by eliminating, as much as possible, the use of man as a source of power, even in small operations, reserving him to be used to direct mechanical power supplied from an inanimate source.

When a man may be made a machine it is time for him to be replaced by a machine, and if mechanical operations are carefully analyzed to the same extent as has been recommended in the study of the management of workmen, it will be found, in very many instances, that no human intelligence is necessary at all, other than may easily be supplied to direct the machines and see that they perform their proper functions.

## Write for Catalogue No. 053

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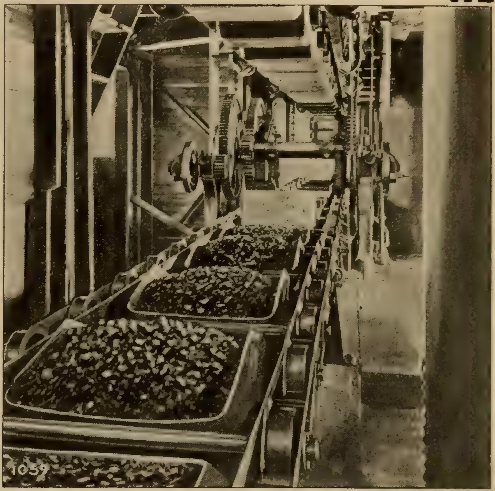

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### Standardization

WE hear a great deal nowadays about standards, and much of the modern methods of efficiency depends upon the establishment of standards upon which the percentage of efficiency may be based. Like everything else, the question of the maintenance of standards is a matter which should be considered with judgment and discretion, and it is a wise man who knows when a standard should be enforced and when it ought to be superseded. To adhere to a standard pattern or design simply because it was a good standard years ago is a mistaken idea, which sometimes appears, and it is such ill-advised conservatism which has caused some able men to refer to the "paralyzing influence of standardization."

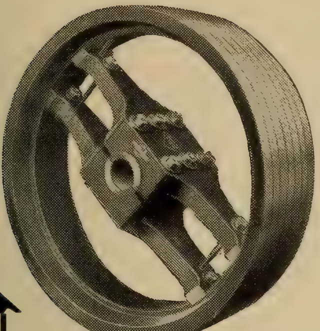
It is true that, for example, to insist upon the thoughtless repetition of an obsolete design is to perpetuate something which ought to be superseded by the product of later ideas and experience, and such adherence to false principles of standardization should be discouraged.

On the other hand, no one will doubt that the general introduction of standard dimensions and threads for bolts and nuts, for example, replacing the innumerable individual sizes, was a step which advanced immensely the development of machine construction.

There is no doubt, therefore, that the wise use of standards is altogether desirable, and it is only the foolish adherence to things which should never have been considered as anything but temporary which has done harm to the maintenance of right standards.

The use of standards is especially important in connection with things which should be made interchangeable. This was shown by the introduction of interchangeable parts at the Springfield Arsenal in the manufacture of firearms, enabling parts to be made in quantity and assembled from stock, besides permitting the parts of injured or defective guns to be reassembled with other stock pieces. From the manufacture of firearms the principle of interchangeability extended to other departments of industry, and in all such cases the essential element of standardization was included.

Nearly thirty years ago the late Wallace H. Dodge undertook to apply the principle of standardization to the construction of pulleys for belt transmission of power. Apart from the advantages of the separable construction, enabling a pulley to be placed at any point on the shaft without disturbing either shaft or other pulleys, he undertook to devise a plan by which pulleys might be kept in stock by diameter and face, independently of the bore for the shaft upon which they were to be carried. This desirable end was secured by adopting a standard size of bore, larger than the usual sizes of shafts to be met, and adding a line of split bushings of standard outside diameter and variable bore to suit the shaft. The result may be compared with the adoption of standard sizes and threads for bolts and nuts; it removed the pulley at once from the position of a special product to that of a staple article of manufacture, besides giving it a length of life dependent solely upon its endurance, independently of its original location. This simple invention, long since the property of the public, is in itself sufficient to cause the work of Mr. Dodge to be held at high value in the history of mechanical evolution; and its application has done much to advance the science of the transmission of power. Those who remember the effort and determination of this remarkable man to advance the department of engineering to which he was devoted, against great obstacles, will always consider that in this apparently trifling detail he made a most valuable contribution to mechanical progress.



"OLD RELIABLE"

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TWENTY-EIGHT years ago marked the birth of the Wood Split pulley with interchangeable bushings. It was the *parent* wheel—the beginning of the Dodge idea of *Standardization* and *Interchangeability.* The idea that stands for greatest modern improvement in power transmission and distribution. Over three million Dodge "INDEPENDENCE" Wood Split Pulleys are in operation, with sales *increasing* every day.

The Dodge Wood Split Pulley is widely imitated. But factory owners appreciate its distinctive merit of design, its high-grade materials and workmanship and perfect balance, its case-hardened face that will wear the edge of diamond-pointed tools. Being split, it can be moved from place to place. Its separable wood bushings adapt it to a wide range of shaft diameters. The usefulness of a Dodge Split Pulley is never done.

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**General Office and Works, Mishawaka, Indiana**

Everything for the Mechanical Transmission of Power.

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| New York | Chicago | Minneapolis | Boston | St. Louis |
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Agencies in other leading cities of the country.

### The Universal Coal Carver

WHILE we are looking after the savings in practical coal mining there is nothing more really worth saving, nothing which it is more necessary to save, than the time and strength of the miner. The operation of coal getting is simply that of cutting out successive portions of the embedded mass. A knife such as that with which a loaf of bread is cut would be the ideal coal carver, but no one yet has found it. Next to that would be a saw, but the saw insists upon conditions which make it too impracticable, and the best we can do by any mechanical contrivance yet developed is to cut in slits as narrow and deep as possible and then to break the coal away by light blasting or otherwise.

The coal puncher idea is to work in a slit horizontally as far as possible under the coal and then break it down. Although it is not a very thin or precise slit that the coal puncher makes, still it suffices, and the device enables the men to get out more of the coal in a given time, but the handling of the machine profitably cannot be anything but real and strenuous work. The puncher, although getting to be extensively used, still insists upon its conditions. Its work is simply that of undercutting in seams nearly level. When pitching seams are to be worked there is additional labor in holding and handling the machine, and even then the incline must be only a slight one.

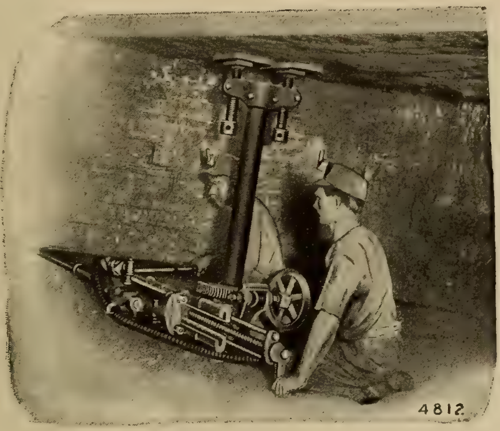
Here the radialaxe comes in to work at any angle just as well as at any other. It does not necessarily take hold in cases where the horizontal working puncher is balked, but it can do all the work of the puncher right through. When the radialaxe is actually working the operator's work in manipulating it is easy. As compared with handling the puncher the man may be said to be resting when he is working. There is more work, in fact, in setting up and securing the radialaxe than in running it, but this is no more than the handling of the ordinary rock drill.

The precision with which the radialaxe bit is carried and guided makes the cut as thin as possible, so that comparatively little fine coal and dust is produced. This precision of location and perfect control of direction constitute an important feature when the radialaxe is used in cutting out a fireclay or slate band, such as often occurs in a seam, and which, if not removed, impairs the market value of the entire output. It would scarcely be thought that it could be provided for the proprietor of a coal mine to be able to boast of the excellence and purity of his product on account of the precision of working of the machinery employed, this being usually the privilege of the manufacturer alone.

Thus far we may have thought of the radialaxe coal cutter as taking its cue from the puncher and doing its work also horizontally or in planes paralleling the seam, but in addition to this it cuts out lines of employment for itself which are independent of the puncher. Its more comfortable, and, as we might say, more natural, way of working is in making vertical cuts, and in some cases by this means it may put the puncher entirely out of business. It may be used to rapidly cut a central slit vertically in the face of the coal, and then it can be broken down and thrown out by light shots, or otherwise.

The work of the machine may be laid out in the mind as the making of either lines or dots. The lines may be horizontal or vertical or at any angle, representing the slits or cuts which it is the business of the machine to make, and the dots are simply holes driven directly forward, as the radialaxe, stopping the radial feed, is besides all else a complete rock drill. Such a machine acts not only to conserve the effort of the coal miner, but also of the material which is being cut, and thus in a double sense becomes an element in conservation of natural resources.

# "RADIALAXE" COAL CUTTER



Here is a standard Ingersoll-Rand product, designed and built by rock drill and coal mining experts for six specific classes of coal mining work, as follows:

Undercutting in a pitching seam.

Shearing in any seam and particularly in entries.

Mining near the middle of the seam.

Cutting out bands in the coal seam.

Mining under or above bands of slate or clay.

Driving entries or headings.

In anyone of these, the "Radialaxe" has no successful competition and has been proved to be a great coal mining economy.

It is really a long-stroke rock drill, with a special radial mounting, making a long, deep, narrow cut in the coal face, at any angle desired.

It can also be used as a rock drill in brushing entries, driving headings, development and similar work.

**COMPRESSORS** **ROCK DRILLS** **CORE DRILLS**

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### The Art of Planing Metal

THERE are yet living a few men who can remember when the planing machine was practically an unknown tool in the machine shop. In those days it was essential that the designer of a machine should avoid any construction which involved the employment of large plane surfaces, and the points at which the component parts of engines and large tools were united were provided with "chipping strips," or narrow raised ridges of metal along the bolting line, in order that the parts might be brought into correct relation by the laborious use of hammer and chisel upon the narrow bearing surfaces thus afforded.

Then came the first small planers, with light tables, moved by chain and sheave, propelled by human muscle applied to the arms of a large handwheel, resembling the steering wheel of an old-time ship; the work being hardly less laborious than the hand chipping process, and the result often not as satisfactory.

As the manufacture of machine tools progressed, and larger power-driven planers came into use, the older methods were dropped and the defects in the earlier machines were gradually eliminated. Differential belt shifters partially removed the shrieking of the open and crossed belts; improved racks and pinions gave smoother action; changes in gearing enabled the machines to be placed parallel to the lathes and other tools in the shop; while quick-return speeds saved a portion of the non-working stroke; and thus the planing machine became one of the standard tools of the machine shop.

Practically all these improvements, however, have been the result of the development of what may be termed the strictly mechanical elements of the problem, and, until recently, it does not appear to have been assumed that any other method was practicable. With the wide introduction of the electric motor for independent driving of machine tools, however, a new line of development appeared.

At first one electric motor was applied simply to drive a machine of about the same general mechanical construction as had formerly received its power from a pulley on a line shaft, the only advantage gained being the greater convenience in getting the power to the machine. As the methods of electrical control were developed, however, the bold stroke was made of eliminating all the belts, clutches, gear boxes, etc., which had formerly been considered indispensable, and applying a specially-designed reversing electric motor, connected directly to the driving shaft. In a planing machine of this type the mechanical connections include only the rack and its gearing, the electric motor being positively connected to the driving gear without clutches or other slipping medium, and all variations in speed, both as to rate and direction, being obtained by regulation of the motor. As is the case with all methods of regulation and control employing electric current little or no physical effort is required to produce the effects, since a shifting of suitable contacts alone is necessary and a very wide range of speed is thus obtainable.

Such a transformation in the method of operating a planing machine naturally brings with it features which fundamentally accompany the substitution of electrical for mechanical control. The number of speed changes is not limited by possible gear changes, but may be multiplied at will. Varying speeds on different parts of the same job, or even at different points of the same cut, become entirely practicable, while promptness of control brings with it all the advantages which are so desirable in the production of precise and accurate work.

The development of such a machine forms another example of the extent to which electricity is becoming interwoven with mechanical construction, to the material advantage of both departments of science.

# The Proper Speeds for Each Step

## of a job result in accurate and finely finished work

## POND REVERSING MOTOR PLANER with Pond Patent Planer Control

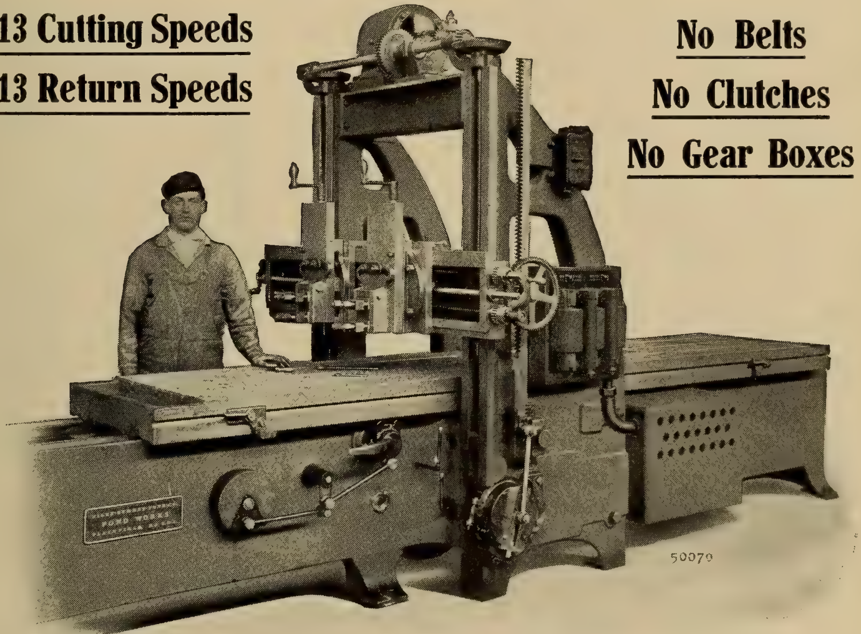
**13 Cutting Speeds**

**13 Return Speeds**

**No Belts**

**No Clutches**

**No Gear Boxes**



**Pond 36-Inch Reversing Motor Planer**

As any one of the 13 speeds may be obtained by simply sliding a thumb piece across an index scale, whether table is stationary under cut, or return stroke, there is no tendency for an operator to use anything but the correct speed at all times.

The motor connected directly to the driving shaft gives a firm, steady, full-powered stroke with a positive and accurate table action heretofore unattainable.

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### Science and Secrecy

WE all remember the old-time skilled mechanic, with his mysterious secrets about tempering, hardening, and other shop operations, and, indeed, many so-called trade secrets were once considered important assets in the value of a business. Sometimes these secrets were really arbitrary and empirical ways of doing things which have since been found to have a really scientific basis, but in very many cases they were wholly imaginary, the good results, if any were obtained, being due either to the individual skill and judgment of the workman or to the general character of the material employed.

With the introduction of the chemical and physical laboratory into the daily work of the manufacturer, however, most of the real secrets were speedily revealed, while the worthless ones dropped by the wayside. Mr. Carnegie once told of the changes made in his establishment by the advent of a German chemist, who wore spectacles, one of these results being the discontinuance of the purchase of a special high-priced brand of pig iron when chemical analysis demonstrated that material of identical composition could be had elsewhere at current market prices; and in such ways the chemist has doubtless done much to remove empiricism and introduce scientific and rational methods.

It is probable, however, that certain materials which have always had a high and deserved reputation owe their standing to constituents either originally unknown or else purposely kept secret, and one of the most valuable results of the application of science to industry has been the demonstration of the ability to produce, with certainty and economy, certain special grades of material for one's self in complete independence of the special dealer in a substance of unknown constitution.

There is probably no material to which these facts apply more directly than to that remarkable substance known as steel. Until recent years steel was known simply as a combination of iron and carbon, and its varying properties were attributed to the varying proportions of carbon present. This, however, was insufficient to account for the remarkable properties of certain brands of steel, and when the chemist and physicist got to work it began to be understood that the character of the steel depended not only upon the percentage of carbon, but also to the manner in which it was present and the heat treatment to which it had been subjected. Furthermore, the chemist found that there were other things besides carbon in many steels, and that even a very small proportion of what were then considered very rare substances made a great difference in the properties of the steel. All this was very interesting, but it was not until the chemist placed in the hands of the workmen the means of producing, accurately, readily, and inexpensively, these special alloy steels that commercial and structural developments began to follow.

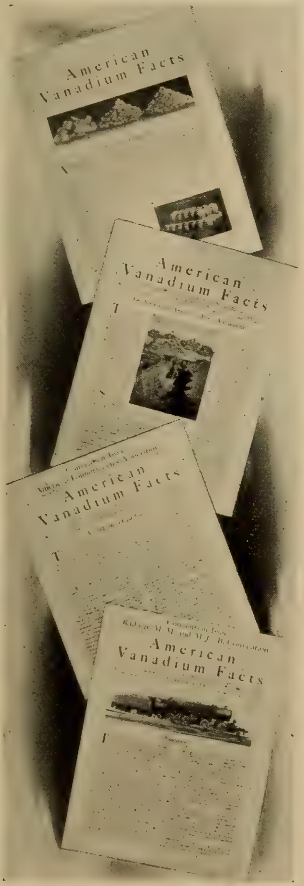
Thus the placing of a definite ferro-vanadium upon the market enabled any steel maker to produce a vanadium steel of any desired percentage with as much ease and certainty as in the chemical laboratory.

It is doubtless true that many manufacturers are using imported tool steel, purchased at high prices and bearing a substantial duty, because of its proved high qualities, and ignorant that these good qualities are due solely to the presence of vanadium. Secrecy hides from the customer the reason for the value of the article which he is buying, and trades on his ignorance; science opens his eyes, and places in his hands the means of obtaining what he wants, intelligently, economically, and independently.

So we have another example of the introduction of scientific methods into daily work, and the passing of the exclusiveness which formerly kept practical men from using scientific results.

# American Vanadium Facts

**Published monthly by the American Vanadium Company**



This is the only regular publication in the world on the industrial application of Ferro Vanadium and Vanadium Alloys.

In an age of steel-making that is largely characterized as the Vanadium Epoch, the contents of this monthly journal must be of vital interest to every man who melts, fabricates or uses steel, iron, or non-ferrous metals.

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## Delivering the Goods

IT is one of the statements which is made of a man who is wholly satisfactory that he "delivers the goods." Some men make attractive promises which they are unable wholly to fulfil; others are capable only of moderate results; but the individual who states clearly what he plans to accomplish, and in due course of time effects the work in a complete and satisfactory manner, merits the high praise included in the expression "delivering the goods."

The forcible character of this expression is undoubtedly due to the fact, not only that the delivery of an article completes the job, but also because the delivery is very often the weak point in the transaction. This is true, both in a general sense and also in a very literal manner. Everyone who has had to do with the delivery of merchandise, both in the heart of a great city and also in the suburbs, knows that the maintenance of a satisfactory and efficient delivery service is a very difficult matter. Sometimes it is good, and at the same time very costly; at other times it is kept within moderate cost by being very imperfectly performed; and at all times it demands continual attention and effort. The layman knows of his own observation of the highways, terminals and shops, what difficulties of congestion and interference continually appear, and he can infer, from the very appearance of inefficiency, how uneconomical this very unsatisfactory service must be.

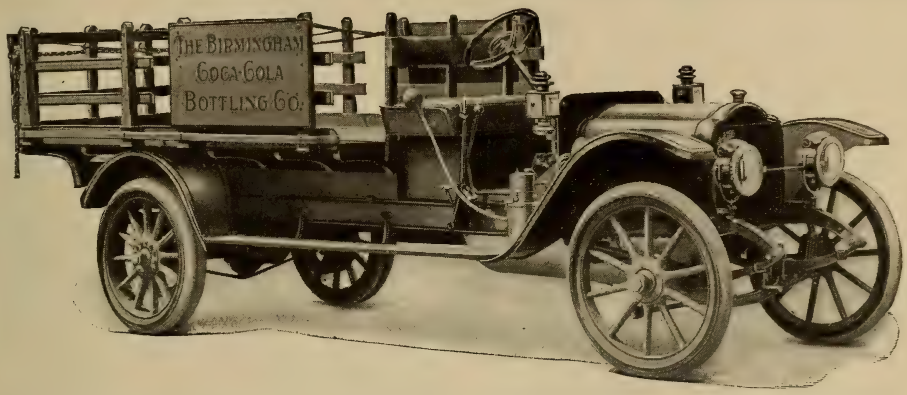
Of late, however, the observer has noticed a change in the method of delivering the goods, and the remarkable increase in the number of motor trucks engaged in delivering merchandise in nearly all large cities and many small ones is most apparent. In a general way it is also apparent that these machines are going about their work in a much more effective manner than was possible with the old horse-drawn trucks.

To those who are familiar with the details of the operation, however, it is evident that the motor truck is not only delivering the goods effectively in the literal fashion, but that it is doing it efficiently as well. With the motor truck of the best character—that is, a motor truck which has been designed skillfully and intelligently for the work, and which has been installed in practically all departments of service and proved its possibilities it has become practicable to solve the delivery problem in all its parts.

This means that the service is vastly increased over the possibilities of horse-drawn vehicles, both in doing things better which were formerly difficult and in doing things which formerly could not be done at all. The active merchant is rendered capable of reaching out for trade formerly entirely beyond his scope, and that without increasing anything except his capacity for delivering the goods, while at the same time he is delivering to his former customers with greater promptness.

It also, under the great majority of conditions, means that this increased service is accompanied with an increased economy. This economy appears in first cost when it is realized that one motor truck replaces two or three teams, and it appears in operation because the mechanically-propelled machine requires the services of no more men than one team, while actually replacing several.

The only thing demanding critical attention in securing these advantages is the necessity of using a truck which has demonstrated its ability to solve the delivery problem in all kinds of actual service; that is, to use a truck which "delivers the goods" in all senses of the expression. The introduction of the motor truck forms one more example of the manner in which machinery is entering into the daily life and work of the people. Machinery is no longer confined to the interior of workshops, but the whole world is becoming one vast workshop, not limited by fences and walls, but formed of our homes, stores and highways.



# Possibilities of Motor-Trucks Unlimited

THERE is practically no limit to the possibilities of motor-trucks in the business world. Every man who has a cartage problem is anxious to know just how motor-trucks will work out under his conditions. But the question is solved—The White Company have hundreds of trucks in operation in almost every conceivable kind of business—under practically every known condition—and there is not a single owner to whom we could not refer a prospective buyer. Not one has been disappointed, but on the contrary each has found that the White truck has exceeded his expectations.

**Increased Service** White trucks serve their owners, first of all, by increasing the service. They make it possible to do things you have never done before—to secure trade you were unable to reach—to be prompt where you were compelled to be dilatory before—to increase your service and thereby increase your business.

**Increased Economy** Under the majority of conditions, White trucks increase the economy of your delivery—not always—there are conditions where trucks only increase the service. The truck replaces two or three teams—is not as expensive to maintain as two teams and requires no more men to operate than one team, saving salaries.

## White Trucks—The Solution

White trucks solve your delivery problem, by increasing your service or increasing the economy of your service, or both, because they are well designed for economy's sake, having the long-stroke, medium-bore engine, which is powerful but economical. They are built for economy's sake because we use the best materials modern science has produced—the special alloys of steel, heat-treated, that are best suited to the various purposes to which they are put. White trucks are made in three sizes, with engine standardized in all types, to simplify the mechanical problem, and make White Trucks adaptable to any business, any special or unusual requirements.

Let us submit a solution of your delivery problem, with catalogue and testimonials of the world's largest users.

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832 East 79th Street, Cleveland

## Steel Windows

IN a recent issue of the *American Architect* there appeared an article which sets forth so clearly the advantages and rapid development of steel windows for manufacturing buildings that we feel sure that it will be examined with interest by the engineer as well as the architect, and therefore reprint it herewith.

The widespread interest in, and study of, industrial and economic problems, relating especially to the betterment of working conditions for labour, has brought about, within two years, a development in factory building construction of vast importance to architects.

During this short time the steel window has largely supplanted the wooden-framed one for use in the better types of industrial construction.

Large employers of labour have long recognized the value of well-lighted, sanitary workshops. An abundance of daylight and ventilation in the factory is one of the strongest productive factors a business can have. The advent of the steel window has made possible a wall construction that yields to the interior all the natural light and ventilation obtainable in a structure of practical design. This is not the place for a technical description of the several makes of steel windows more generally known. Most architects are already familiar with the relative merits of these, but the fact that within a period of about two years the steel window has so solidly intrenched itself in favor with the authorities on the subject of industrial buildings should lead the progressive architect to inform himself thoroughly of the underlying causes of this development and learn well the lesson of popularity.

The simple reason why the steel window is used to-day, in preference to the wooden one, is broader in its application than the energy and enterprise displayed by the makers in the sale of it. Daylight and fresh air are vital to our very existence. The health of factory workers is immeasurably affected by the abundance or dearth of both. An article of building construction which promotes healthier conditions in shops and factories can scarcely be placed upon the common level of a trade commodity, but is sure to be regarded as a necesity for the welfare of mankind. This is the real reason behind the popularity of the steel window, and it is supported by others of comparatively lesser importance, but still of considerable value from the architect's and owner's standpoint.

For example: First, in the modern substantial type of factory building, wooden windows are not exactly in keeping with the collateral construction. An article of greater durability is required, which will, at the same time do away, to a great extent, with the heavy upkeep expense to which wooden frame windows are liable.

Second, in this modern day, no material should be used in factory construction which is fuel for fire.

The most important consideration, of course, in connection with the use of steel windows, is the influence they must surely have on the health of our mass of working people, and for that reason alone their introduction here met with immediate favour on the part of thoughtful men.

Considered as an investment, there are many arguments to be offered in support of the use of the steel window in factory construction. While its first cost is in some cases greater than that of wood the subsequent saving in maintenance charges and the increased life of the window represents another step in the direction of absolutely fireproof factory buildings at a cost which is easily within the limits of what may be called judicious investment for plant.

The alert manufacturer has been quick to see that there is a profitable side to an evolution in building methods which owes its popularity to the humanitarian principles involved.

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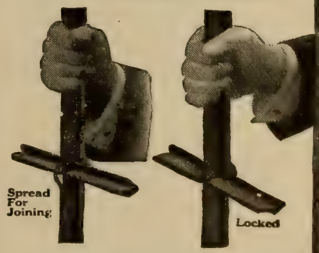
**The "Fenestra" Joint**



**Practically No Metal Lost**

# FINANCIAL NOTES

**A department of information on industrial and other securities of value to investors and men of affairs.**

## OF THE INDUSTRIAL WORLD

**SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible, the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.**

**CHARLES EASTON, Financial Editor.**

### The Situation

UNDER the influence of a decidedly improved business sentiment greater activity is being manifested in all lines of trade. Hopeful opinions as to future trade conditions, instead of pessimistic prophecies, are being voiced by men of affairs, with the gratifying result that confidence is being restored, while the fear and uncertainty which has seemingly held the commercial world in its grip for an unfortunate length of time is being destroyed.

During the summer months it is to be expected that the "Captains of Industry" should issue a general order to "mark time." However, present conditions justify the opinion that the early autumn will see this order revoked, and a forward movement started such as we have not seen in the industrial world for several years.

New York banking interests are always quick to sense a change in the business situation. It is a fact that they are now quietly disposing of their low-rate bonds with a view of using the money to a better advantage in commercial channels.

The principal business centers throughout the country report a better tone and a moderate increase in actual trade.

The railway business is picking up, and steel manufacturers are receiving increased orders.

Foreign trade is largely in excess of last year, and it is, next to the favorable agricultural condition, the brightest spot in the whole business situation.

The political atmosphere is clearing, and President Taft's address to the New York Bankers' Association continues to be favorably discussed. What the country needs is business statesmanship, rather than political leadership, a situation which gives Mr. Taft unusual opportunities to show his ability as a constructive statesman.

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It is said that in France there is available capital for investment in American securities of at least $250,000,000 a year. In view of this it is unfortunate that such a clumsy fumble should have been made in listing one of our best industrials on the Paris Bourse.

*Question.*—What is your opinion of Erie Common?

*Answer.*—The purchase of Erie Common at any price would be more a speculation than an investment. As a low-priced speculative stock Erie Common has some merits; that is, it offers a chance to resell on a rising market at a profit. In its favor are the undoubted facts that the road is in better physical condition than it has ever been and is getting a larger proportion of the traffic for which the trunk lines compete, as well as more local business. It will not, however, be in line for dividends for several years to come.

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It is an interesting fact that the Western Atlantic Railroad, which is owned by the State of Georgia, annually pays $125,000 more than the State's total interest charges. The road was completed in 1850, and extends from Atlanta to Chattanooga. It was leased in 1890 to the Nashville, Chattanooga & St. Louis.

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*Question.*—What decision has been reached as to to the reorganization of Standard Oil?

*Answer.*—There is a general denial of reports regarding the plans for disintegrating the Standard Oil Company of New Jersey and resolving it into its constituent elements, each to stand on its own bottom. It is, however, admitted by Vice-President Moffitt that the general principle of the whole reorganization will be the distribution of the stock of the many companies which compose the Standard Oil of New Jersey to the present holders of Standard Oil stock.

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An amended bill in the Government suit against the Lehigh Valley Railroad company has been filed in the Circuit Court in Philadelphia, which is in accordance with the decree of the Supreme Court of last April. It is spoken of as a final effort to "Vitalize the Commodities Clause" in the Inter-State Commerce law, and is aimed directly at the coal land interest of railroads.

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**The Delaware and Hudson Company**

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*Question.*—Would you advise the purchase of American Tobacco 4's?

*Answer.*—American Tobacco 4's are the subject of many discussions and are variously regarded, but no one has the slightest doubt that they are thoroughly safe. Should the court order a redemption of these bonds they would at current prices offer excellent speculative opportunities. While such court action is possible, it is hardly probable.

---

The gross earnings of the entire railway mileage of the country in March of this year are estimated to have been $34,000,000.

---

*Question.*—What do you think of Westinghouse Electric?

*Answer.*—It is to be regarded favorably. For the year ending March 31 the gross earnings of the Westinghouse Company were $38,119,312, a gain of $8,870,630 over the previous twelve months. The net profits were $5,608,765, as against $2,055,787.

---

Our exports in May exceeded all previous records by $18,000,000. They were nearly double those of May, 1909, or 1910. For the eleven months ending with May our trade exceeded any previous year by $288,000,000.

---

*Question.*—Do you regard 6 per cent. bonds issued against New York real estate as being safe?

*Answer.*—We do, providing the company issuing same is in the hands of capable and trustworthy men. Money properly used in the investment and improvement of New York real estate will earn considerably more than 6 per cent.

---

The Baldwin Locomotive Works, which has been operating under that name since 1831, has recently been taken over by the Philadelphia Locomotive Works, and the capital of the new company placed at $40,000,000. This is the largest industrial concern in the "Quaker City."

*Question.*—What do you think of the copper metal market?

*Answer.*—Assuming that the figures given by Mr. Daniel Guggenheim are correct, there is good reason to anticipate an increased demand, accompanied by advancing prices. Mr. Guggenheim claims that more copper has been produced during the last twelve months than at any time in the history of copper production, and that the consumption has been 40,000 tons in excess of the production. To a very great extent, however, this enormous increase in copper consumption has been taken care of by Germany and England. Sentiment is improving towards the better copper shares.

---

The National Biscuit Company will erect a new factory in New York City, to cost $1,000,000 and employ 2,000 men. The shares of this company have been attracting the attention of investors for the past few months.

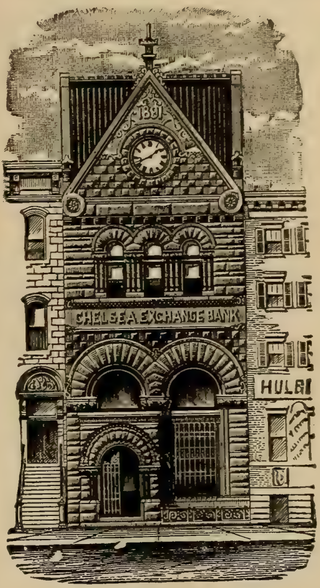
---

*Question.*—What do you think of the Virginia Iron, Coal & Coke Company's stock at present prices?

*Answer.*—It is selling too high for a non-dividend paying security. The company owns 120,000 acres of valuable coal land, as well as 180,000 acres of ore and timberland. The stock has intrinsic value, and for a long pull might be profitable.

---

The earnings of the International Steam Pump Company for the past six months have shown a fair increase over the corresponding period of 1910. The corporation's income is reasonably certain, because about 60 per cent. of its gross business is derived from repairs, renewals and a trade pump demand, which is practically constant. Of the total amount of pumping machinery turned out in this country about 70 per cent. comes from International plants. Recent orders of importance include that for the new municipal water works at Buenos Ayres, costing $1,000,000.



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Most of the purchases of Panama loan bonds appear to have been by individuals, schools, public institutions and trustees of estates, and not by banks, as is usually the case. The average price was $102.50, which means that the credit of the United States is higher than that of England, Germany or France, the securities of which sell at a discount.

The new issue of Great Northern bonds is reported to be selling readily. Sales appear to have been made to various dealers at various prices, resulting in more or less confusion and bad feeling.

When an Erie Railroad locomotive displays a breast plate with a red background it means that the driver has attained efficiency beyond the average; and when a man's name appears upon the cab it means that the driver has attained to almost a perfect state of efficiency. A good idea.

It is proposed by American financial interests to establish a bank in Paris in connection with certain European capitalists.

It is stated that the Standard Oil holdings of John D. Rockefeller are worth at present prices more than $167,000,000; H. Payne Whitney, $27,000,000; Henry M. Flagler, $11,000,000; while five others hold more than $5,000,000 each, and eighteen more than $1,000,000 each. The yearly income from these earnings will be seen to be a considerable item, when it is recalled that in the twelve years beginning with 1899 the average dividend paid has been a little larger than 41 per cent.

It will surprise many people to know that the total exports of automobiles in 1910 reached the comfortable figure of $13,000,000. In the nine months ending with March of this year the increase in the exports of automobiles over the previous nine months was 50 per cent.

The shipments of wheat and flour from the United States between April 6 and May 18 of this year totaled $15,868,155, against $14,667,626 in 1910 and $10,000,000 in 1909.

In the first 48 postal savings banks opened for business there was deposited in five months $390,666. A second group of 45 opened on May 1 made a most favorable showing, having received $70,749 in deposits up to June 1, or 14½ per cent. more than the first group received in the same length of time. The Postoffice Department anticipates a total deposit of $1,000,000 in the postal savings banks by July 1. The largest deposits to May in the offices opened January 1 were, in the order of amounts, at Leadville, Col.; Anaconda, Mont.; Norwood, Mass.; Carthage, Mo.; Dubois, Pa.; Manitowoc, Wis.; Ashtabula, O.; Glove, Ariz.; Pittsburg, Kan.; Carson City, Nev.; Johnson City, Tenn., and Bessemer, Ala. The smallest showing was made by Newberry, S. C.

The Eastman Kodak Company has declared an extra dividend of 5 per cent. on the common stock.

The Chicago City Railways has sold $50,000,000 first mortgage 5 per cent. bonds to Harris, Forbes & Co. and the National City Bank.

The statement of the Baltimore & Ohio Railroad, as of June 30, shows a surplus of $1,126,000. This is a decrease of $3,645,000 as compared with the previous fiscal year. The statement explains that this decrease is entirely offset by the increase in its rates of pay, which for the year aggregated about $2,300,000, and an increase in interest charges, incident to $50,000,000, 4½ per cent. notes, issued for equipment and betterment. As was expected, the company declared the regular dividends.

The recent purchase of Chinese bonds by a group of American banks means that another $12,500,000 of American funds will go abroad.

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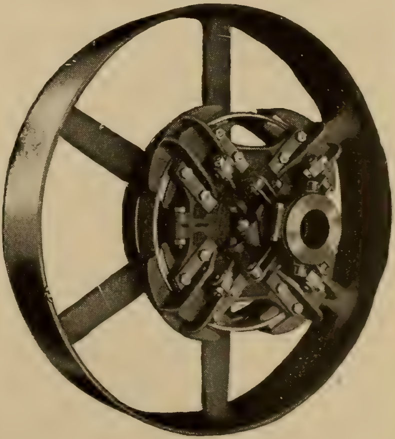

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The Electrical Engineering Department of the Massachusetts Institute of Technology received an appropriation of $3,000 from the Edison Electric Illuminating Company of Boston to be used in an investigation of the relative operating reliability and costs of electric trucks, gasoline trucks and horse trucking, for the purpose of determining to what degree electric trucks are adapted to compete with gas and horse trucks in the city of Boston. This investigation will cover the cost of delivery of good in different ways. It will include all questions which concern electric trucks, including the influence of the different kinds of city pavements on cost of delivering goods, and the effects of different routings of the vehicles. The investigation will be partly theoretical, but it will be planned to determine practically what it ordinarily costs to deliver goods under city conditions. This part of the investigation will be accompanied by actual observations extended over a period of many months. At least a year will be occupied in this work, and Mr. H. F. Thomson has been appointed Research Associate to carry on the work under the direction of Professor Pender.

---

Statistics compiled by the United States Geological Survey show that the production of spelter or metallic zinc from ore for the first six months of 1911 was 140,196 short tons, a gain of more than 5,000 tons over half the record output of 1910. Of this production 5,135 tons was made from foreign ore. Spelter stocks were reduced from 23,232 tons to 17,788 tons. Imports remained about the same, but exports were nearly double those of half the preceding year. The apparent consumption of spelter was 135,497 tons, an increase of more than 12,000 tons over the half of 1910, but about the same as in half of 1909. The average price of spelter at St. Louis for the period was 5.36 cents per pound, the London average being .2 cent less per pound. During the latter part of May and the first part of June the average

London price was about .1 cent higher than the corresponding St. Louis prices. Under this stimulus the May exports of spelter, zinc ore and dross were largely increased over those of the preceding months.

---

The transmission of power is a matter which interests every manufacturer, and hence the pamphlet of the Hill Clutch Company, discussing the link between the engine and the machine, is timely and valuable. Shafting, pulleys, clutches, bearings, hangers, etc., are all discussed in a manner which conveys both instruction and information, and further facts are promised to those who will take the trouble to write for them.

---

Coal costs money, and anything which enable the purchaser to get the most value out of the coal he buys should certainly interest him. The American Stoker Company, in its Bulletin A-2, discusses the true scientific method of burning coal, not only under steam boilers but also in industrial furnaces, as for forging, plate manufacture, drop forgings, annealing, drying and all kinds of similar work. A proper furnace permits the use of fuel of the cheapest kind, reduces the amount of labour required, aids in the prevention of smoke and provides full control of the operations. Details for any special department of work may be obtained from the American Stoker Company, New York.

---

Concrete foundations are now fully appreciated and the principal point lies in the choice of the system best adapted to the particular case under consideration. The MacArthur Concrete, Pile and Foundation Company has recently issued a book devoted to the subject of the Pedestal Pile, a name given to the peculiar form of construction, in which a mass of concrete at the bottom of a core is rammed until it is forced into the surrounding soil and followed by a cylinder of concrete, the whole form-

*Continued on Page* 76

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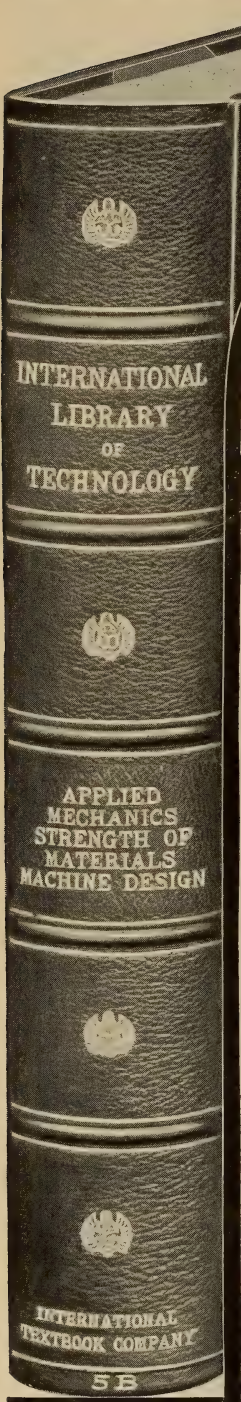

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| Cotton Seed Oil Mills | 902 |
| Cotton Mills | 835 |
| Electric Power Plants | 938 |
| Electrical Supply Dealers | 672 |
| Engineers | 351 |
| Flour and Grist Mills | 2801 |
| Furniture Mfrs. | 470 |
| Hardware Dealers | 6049 |
| Ice and Refrigerating Plants | 949 |
| Knitting Mills | 182 |
| Machine Shops and Foundries | 1286 |
| Mill Supply and Machinery Dealers | 461 |
| Mines and Quarries | 1466 |
| Phosphate Mines & Fertilizer Mfrs. | 459 |
| Planing Mills | 2034 |
| Plumbers and Steam Fitters | 1829 |
| Rice Mills | 78 |
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---

In view of the general interest in the subject of the prevention of accidents to employees the little book issued by the Norton Company, of Worcester, Mass., and devoted to the subject of Safety as Applied to Grinding Wheels, will be found most acceptable. Accidents from grinding wheels have been numerous and disastrous, and hence the responsible makers of grinding wheels have been found desirous of doing all possible to secure the safety, both in the manufacture and testing of wheels, and in the protective devices by which the operatives may be guarded. This little book will be found full of instructive ideas for the progressive manufacturer, and should be in the hands of every engineer who desires to secure maximum efficiency, both of men and of machines.

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The sixth edition of "Hy-Rib" has been issued by the Trussed Concrete Steel Company, of Detroit, Mich. The book, which is fully illustrated, describes the application of Hy-Rib steel sheathing in roofs, floors, walls, sidings, partitions, ceilings and furring, and shows its ever-extending use in every field of building operations. The Hy-Rib steel sheathing has been found to greatly reduce the cost of building work, because it does away with expensive field labour and centering and saves time in erection, yet gives the most possible permanent, enduring, fireproof construction, that is more economical than wood, which burns and rots. A copy of this book will be sent free on request.

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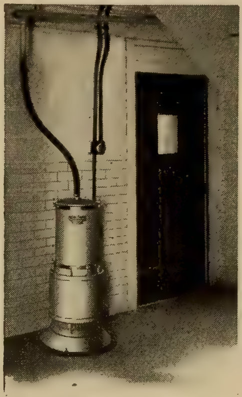

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## PERSONALS

Mr. Samuel H. Keefer, a valued employee of the Niles-Bement-Pond Company, died at the Muhlenberg Hospital, in Plainfield, N. J., under an operation for appendicitis.

Mr. Keefer was the chief electrical engineer of the company, and is known especially by his ingenious and successful design of the reversing-motor planing machine built by them, and he was also the designer of other important electrical improvements in machine tools now under development, inventions with which his name will be associated for many years.

He was a graduate of Stevens Institute, at Hoboken, in 1906, this training being followed by an apprentice course with the Niles-Bement-Pond Company, and his death at the early age of 30 years, leaving a widow and young son, will be keenly felt by all his friends.

---

Mr. Ralph Modjeski, the well-known bridge engineer of Chicago, received the honorary degree of Doctor of Engineering from the University of Illinois at the recent commencement in June. Dr. Modjeski made an appropriate address at the Senate dinner, which followed the commencement exercises, and spoke of his satisfaction in seeing the development of the University of Illinois during the years in which it had been under his observation.

---

The degree of Doctor of Engineering was recently conferred by the Massachusetts Institute of Technology upon Mr. R. L. Jones, a graduate from the electrical engineering course of the institute, who has followed graduate studies particularly relating to alternating current theory and the transmission of power, electrochemistry, organization and administration of public service companies, and mathematics. His research has been on the subject of heat treatment of transformer steel. By using an induction electric furnace he has been able to carry on some interesting and important investigations from which some new results have been discovered which it is believed will be valuable. Mr. Jones goes into the employ of the Western Electric Company in their division of research and development.

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### Massachusetts Selects Experts to Investigate its Departments

Gov. Foss of Massachusetts has recently selected Mr. Clinton H. Scovell, of Clinton H. Scovell & Co.; Mr. Charles L. Harpham, of the Harpham & Barnes Company, and Mr. Harvey S. Chase, of Harvey S. Chase & Co., all of Boston, as experts to investigate the departments, commissions and institutions of the State under the provisions of Chapter 82 of the act of 1911. To Mr. Scovell the Governor has assigned the investigation of matters relating to public works and buildings, public utilities and the natural resources of the State; to Mr. Harpham the work comprised within the general divisions of health, education, charity and civil service, reform schools and prisons, while Mr. Chase is to have charge of the third division, which relates to auditing, accounting and statistical methods.

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### Gifts to the Massachusetts Institute of Technology

The State of Massachusetts has appropriated for the Massachusetts Institute of Technology $1,000,000, to be paid in ten annual instalments of $100,000. The Institute has also received a gift of $500,000 from T. Coleman Du Pont, and is made residuary legatee under the will of Mrs. Emma Rogers, widow of William B. Rogers, first president and founder of the Institute.

The Du Pont gift will be used either for a new scientific building and its equipment or for a new site for the Institute.

Still another gift announced is a scholarship fund of $600,000 under the will of F. B. Green.

PRACTICAL Gas Engine Books

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### Building the Factory

Two things especially must be considered long and carefully when choosing a site. One is the transportation facilities and the other is the proximity of a good labour market. As regards the former, it must be decided, first of all, whether the consumption of the goods to be manufactured will be restricted to a certain locality or whether it will be widely distributed, either locally or internationally. In either case, so far as the domestic distribution is concerned, the plant should be as nearly as possible in the geographic centre of the region where the greatest demand is looked for. If there is a prospective world-wide market it will, of course, be more advantageous, all else being equal, to locate at some point on the seaboard. It is, however, possible that the supply of labour or the proximity of an abundance of raw material will be nearly as important factors in location as the market possibilities. This can be calculated with a certain degree of accuracy by a careful study of freight rates and tonnage.

One of the greatest mistakes, states Mr. J. Anderson Wyatt, in *Harper's Weekly,* that the projectors of a manufacturing plant can make is to figure on drawing their labour supply from concerns already in operation. This not only promotes bad feeling among competitors, but it also increases the cost of labour considerably above what it should be under normal conditions. Where there is a plentiful supply of the right kind of labour—or of anything else—prices are low compared with a location where satisfactory help can be secured only by outbidding someone else in the same line.

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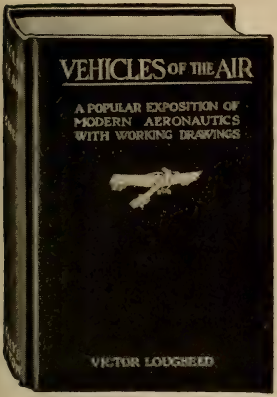
The Pan-American Union, Mr. John Barret Director-General, has issued, from the headquarters of the Bureau, at Washington, D. C., an instructive and interesting book entitled "Rubber and Its Relatives," which is very fully illustrated.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# THE LATEST CATALOGUES

THE latest issues of the Records of The Baldwin Locomotive Works include Nos. 69 and 70, these discussing respectively the Mallet Articulated Locomotives for the Atchison, Topeka & Santa Fé Railway System and the Walschaert's Valve Gear. The Santa Fé road has been most progressive in the introduction of heavy locomotives, and the Baldwin Locomotive Works has carried out the ideas of their engineers in a most effective manner. This bulletin describes the Mallet locomotives, both of the rigid and the flexible boiler types, with Jacobs-Shupert fireboxes and Jacobs superheaters, with details of construction, representing the heaviest and most powerful locomotives yet constructed for service in the United States.

Record No. 70 is of especial interest, as showing how the pioneer work of the Belgian engineer Walschaert has finally been recognized, with details of its application to American locomotives of different types. This valve gear has long been recognized on the Continent as most desirable and effective, and its tardy recognition in America is most interesting. This bulletin examines its advantages and defects in detail, with examples of adjustment and correction, and will be most acceptable to modern designers of locomotives. The late William Mason, of Taunton, endeavoured to introduce this gear into America, and used it on the small locomotive built by the Taunton Locomotive Works for use upon the railway in the grounds of the Centennial Exposition at Philadelphia in 1876, but his example was not followed by other builders, and it has not been until the use of four cylinders de-

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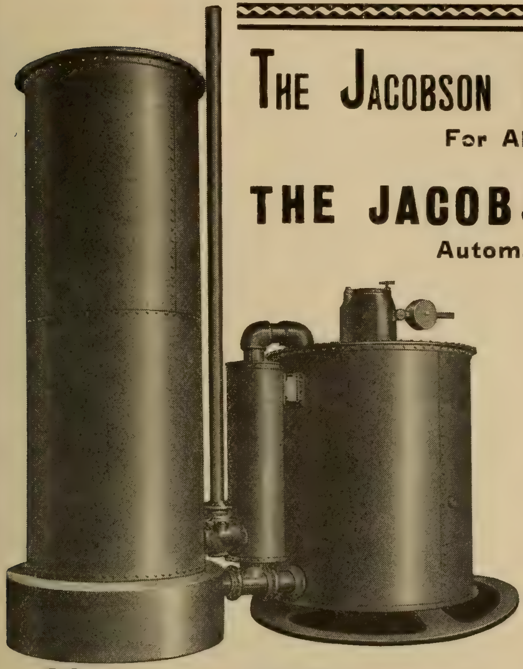

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manded the employment of both inside and outside valve gears that it has been accepted by American and British designers, although both Zeuner and Auchincloss have advocated it in their treatises.

---

The General Electric Company has recently issued Bulletin No. 4845, Turbine Steam Generators of the Curtis Type, intended to be operated at speeds of 3,600 revolutions per minute, the maximum speed possible for use with 60-cycle alternating-current electric generators, these machines ranging in size from 100 to 1,000 kilowatts. These units are especially adapted for industrial and lighting plants requiring the economical generation of a moderate amount of power. They include the desirable combination of high steam economy, low operating cost and entire reliability. Illustrations are given of these machines as installed in manufacturing establishments of various kinds, together with details of the different elements of construction.

Another interesting publication of the General Electric Company is Bulletin No. 4851, entitled Electricity in the Service of Steam Railroads. This includes illustrated descriptions of power houses with generating plant for a number of different lines, views of electric locomotives employed on main-line service, and also electric motors used in driving machine tools in railway machine shops, thus covering several distinct application of electric power to railway service.

---

The Ansonia Brass and Copper Company has issued a convenient little pamphlet devoted to the properties and advantages of Tobin Bronze, a material adapted for a great variety of mechanical constructions. In this booklet there are given data concerning the tensile strength, specific gravity, resistance to acid corrosion, and general mechanical properties of the material, together with tables of weights and results of tests. A number of testimonials from prominent engineers bear witness to the valuable properties of Tobin Bronze in a variety of structural work.

---

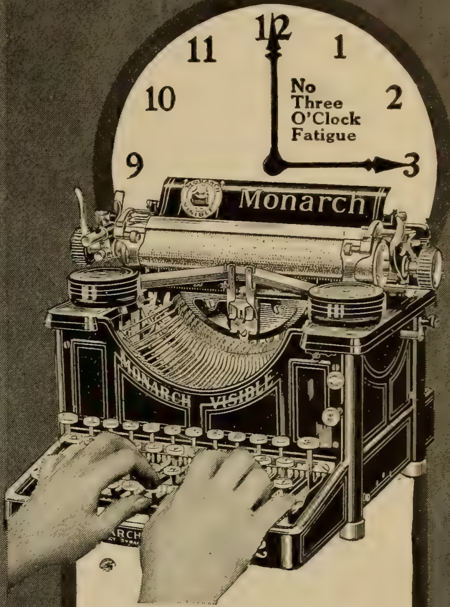
Bulletin No. 1009, issued by the American Locomotive Company, is devoted to the 230-ton articulated compound locomotives built for the Baltimore & Ohio Railroad. Engines of this type have been used by this railroad since 1904, but the later machines have been much heavier than the former ones, and the operative results of all have been most satisfactory. The Bulletin gives data and results of performance, with profile of grades and details of construction, and is altogether instructive and interesting to all connected with modern problems of transportation.

---

The Standard Steel Works, of Philadelphia, has issued a new catalogue devoted to steel tires for steam and electric railway service, giving the specifications of the American Society for Testing Materials, with diagrams and facsimiles of dimension blank for ordering. A large variety of steel tires is shown, and of especial interest may be noted the built-up crank axle and driving wheels designed for use with four-cylinder compound balanced locomotives. The book is admirably printed and illustrated.

---

The removal of dust, shavings, lint and other light debris from manufacturing establishments is best effected by the use of an exhaust current of air, and hence the Bulletin No. 136, issued by the Green Fuel Economizer Company, of Matteawan, N. Y., is of interest. The exhaust fans manufactured by this company are intended for use at low or standard speeds, and adapted to remove the material with the least expenditure of power and in the most effective manner. Tables of dimensions and arrangement are given, enabling the most desirable form of installation for any particular case to be determined.



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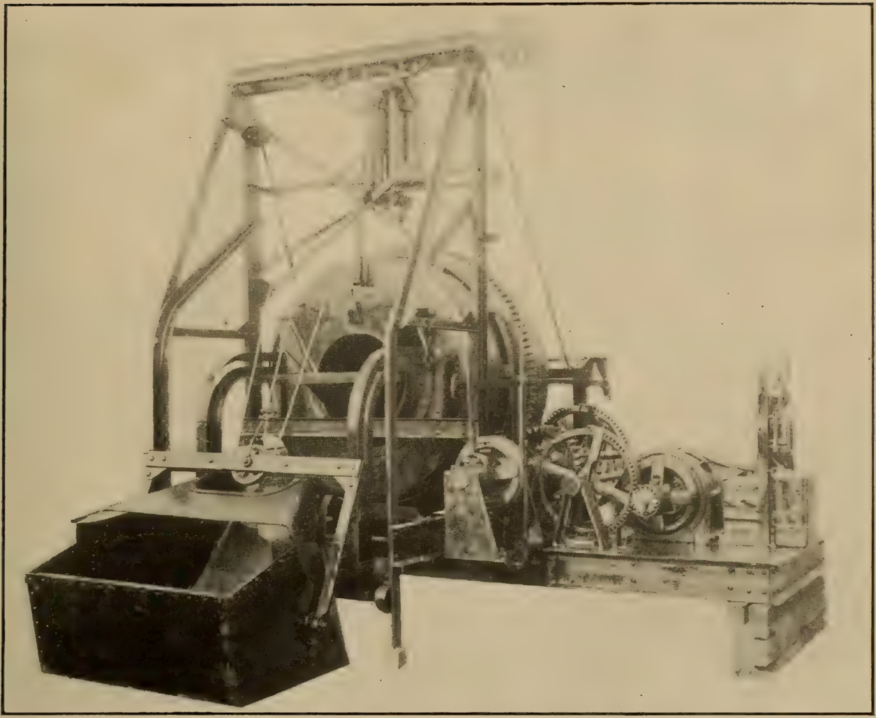
**Automobile Testing.**

Work as a tester in an automobile factory, says George D. Wilcox, the assistant general manager of the Regal Motor Car Company of Detroit, offers splendid opportunities to the young mechanic. It is healthful and fascinating work. It is a quick builder of reputations. Most of the famous racing drivers you hear so much about got their training as testers and some of them are no manufacturers; there's Lancia, foreign dare-devil, for instance. He is now a manufacturer.

Formerly the tester's work started in the fall and continued through the winter and spring, when driving is at its worst. Now the tester is putting the new cars through their paces all year around.

The tester takes the car from the assembly department, after its working parts have been packed with grease and shot full of oil, for its maiden run. The road work it is put through is severe. It has to be, for the tester must make a report on the speed-going and hill-climbing abilities of the machine. He has to make all his own adjustments in every part of the car and is required to make a detailed report of what his eye and ear have told him about the car. If changes are required to make the auto a good auto, it's the tester who tells the factory superintendent.

After the first paces have been gone through, the auto passes to the head tester and then it has its body fitted on and is sent to the paint shop. That's where the tester rides "on velvet," but his work here is all-important. The car must work harmoniously, without any pounding or clanking, and the tester has to keep his ears and brain working to determine the running qualities and the regularity of the engine. Then the car is put back in the factory, cleaned off, the final adjustment of brakes and timing gears are made, the brass is all polished up and the car is tagged for shipment.



LAKEWOOD CONCRETE MIXER EQUIPPED WITH SIDE LOADER AND ELECTRIC DRIVE.

### Modern Concrete Mixers

THE extent to which concrete is replacing ordinary masonry in engineering structures may be partially realized by the development of machines for preparing the material from which concrete is made. Formerly, when a little concrete was required for a foundation or similar job, it was mixed on a plank bed by a man with a hoe, much in the same manner as ordinary mortar. To-day, when thousands of cubic yards are required, and practical uniformity in the product is essential to the permanence and safety of the structure, the cement, stone, sand and water must be mixed in definite proportions by machinery, since only in this way can the continuous quantity of correct material be made.

In the illustration there is shown a most effective machine for the production of large quantities of uniform concrete, this being known as the Lakewood Mixer, built by the Ohio Ceramic Engineering Company, of Cleveland, Ohio, and represented in New York by Mr. W. Van R. Whitall, of No. 30 Church street.

The advantages of this mixer appear both in the construction and operation. The blades are so constructed and arranged on the inside of the revolving drum as to permit a thorough mix and rapid discharge without overspeeding, thus avoiding unnecessary wear and tear. The unusually large opening enables the use of a very wide chute and large charging bucket, permitting the machine to be charged with great rapidity. In like manner the very large discharge opening and wide discharge chute provides an extremely rapid discharge; both of these points causing a corresponding saving of time and increase of capacity. The use of extra heavy steel plate in the construction, together with the rigid frame and heavy central driving gear and pinion, substantiates the claim that the Lakewood Mixer is built to last.

### Availability

ONE of the characteristics of the American machine shop or manufacturing establishment appears in the idea of continual change and growth. It is impracticable to plan everything beforehand, and when changes are made they have often to be carried out with the loss of a minimum amount of time. In the majority of cases the value of the time consumed in making a change is greater than any other item in the cost of the job. This means that everything must be ready before productive work is interrupted, otherwise something is sure to happen to delay the completion of the work within the limit of time.

If it were practicable to order everything beforehand, it might be possible to avoid many provoking delays, but nearly always there are parts which cannot be determined until the job has been started, and thus the work is dependent to a great degree upon the co-operation of others, and frequently upon those whose actions cannot be controlled.

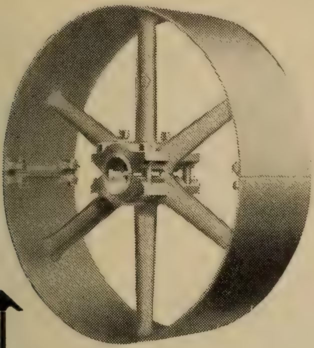
Thus, in the introduction of power transmission into an extension of a factory, the dimensions and locations of pulleys upon the shafting are often dependent upon the placing of the machines and upon their speeds and the belt capacity demanded. Unless all these points are positively known beforehand it is impracticable to order and obtain the pulleys in advance, if the common solid cast-iron pulley is the kind employed.

The time wasted in arranging the power transmission before productive work can be started may exceed in value the entire cost of the improvement, and anything which avoids delay should be welcomed as a distinct means of saving money. So far as the pulley question is concerned, the remedy for delay is found in the use of pulleys which are interchangeable, and which may be either taken out of the dealer's stock or taken from some other place in the manufactory where they are not needed. This means that the pulley must be readily taken down from its former position, without requiring the disconnection of shafting or the removal of other pulleys, and be capable of replacement upon a shaft which may or may not be of the same diameter, without disturbing hangers, couplings or other pulleys.

These requirements are partially met by the use of split pulleys, made in halves, and bolted together, since this construction solves the question of removal and replacement at any point on a shaft. The matter of bore can be met only by the employment of split bushings, and this simple expedient has been found to work out very satisfactorily in practice. The bore of the pulley is made larger than the diameter of any shaft upon which it may be used, this bore being the same as the outside diameter of the bushing, and thus a selection of bushings of various bore and constant diameter enables any pulley to be put upon a shaft of any diameter within ordinary requirements of machine shop work.

Apart from the time-saving effects of this simple modification of the ordinary pulley, the possibility of using pulleys again and again in different places gives them an almost indefinite life and saves them from being relegated to the scrap heap long before their real usefulness is past.

An essential of the split pulley is that it shall be so well designed and made that it will be fully as strong and rigid as a solid pulley, and it is because some of the earlier attempts to make split pulleys were lacking in these points that their advantages were not always recognized. When, however, the split cast-iron pulley is designed with full regard to the conditions under which it is to be used, and is provided with proper set screw and compression fastening, it provides all the strength and rigidity of the solid pulley, together with the advantages of interchangeability and adaptability which no solid pulley can possess.



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Dodge Split Iron Pulleys are made to secure the maximum of strength and rigidity. Made of cast iron—hence non-flexible. The rim is cast whole, split by a fracture and when drawn together on the shaft is practically a solid rim. There isn't a riveted joint in the pulley; it can't bend out of shape, and it is fastened to the shaft by compression, reinforced by two set screws. Goes on to stay—runs straight and true.

We want to explain to you the "Dodge Idea" and tell you in full the facts about the Dodge line, which includes "Everything for the mechanical transmission of power. Let the Dodge Staff of Expert Engineers help you untangle your knotty transmission problems—a service free of obligation.

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### Independence in Mine and Quarry

INDEPENDENCE is the unique ideal. It is a thing so desired and longed for that the most strenuous and protracted exertions of earnest men and the most sweeping sacrifices of all other things have from time immemorial been made to secure it. The value is in the thing itself, and is so intrinsic and enduring that too much can never be paid if necessary to secure it. Often it comes cheaply or for nothing at all, but the value inheres just the same.

Independence applies and has its value in business and industry just as much as in sociology, and ostensibly is as constantly sought for, but is not always recognized and appreciated and appropriated as soon as it comes in sight and reach. This is not to be wondered at just now, as the work of the most pronounced and efficient of modern industrial emancipators, which electricity surely is, has not been all and straightly for the fostering of general and permanent independence. Electricity is a wonder in power transmission, and by its alertness and adaptability has driven out some of the most established of old-time "facilities." Especially has it driven out, among other things, the small individual steam-operated apparatus, doing the same work of pumping and hoisting and hauling more readily, efficiently and cheaply.

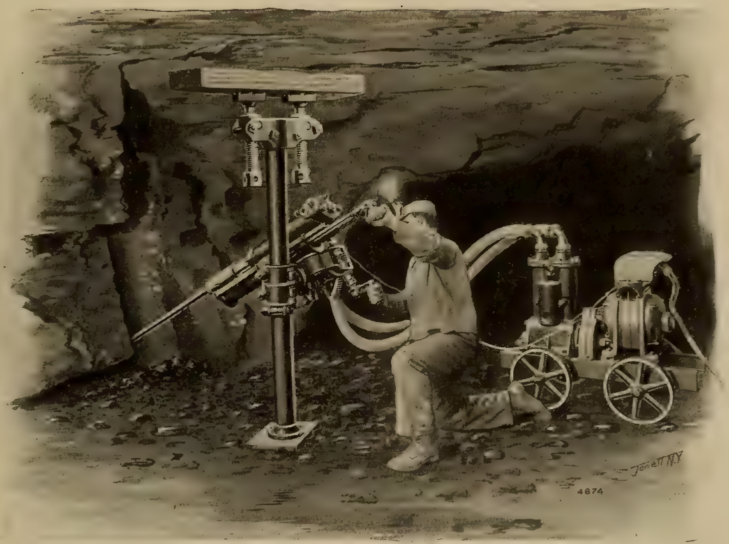
Before, however, electricity began to show what it could do and how well it could do it, by actual performance in various fields, compressed air had become very firmly established in mines universally, and in quarries quite extensively, for the driving of the rock drills, so that in many cases in recent years it has happened that steam and compressed air and electricity have all found employment side by side where one of the agents could and should have done it all.

This is a kind of thing which is not to be tolerated in these days, and if there has not been a formal declaration of independence the work of simplification, which is emancipation, has begun. One power transmitter instead of three is what we are to aim at. It has not been a difficult thing to supersede direct live steam for scattered and isolated service. Its wastefulness and inconvenience as compared with either air or electricity is conclusive at once against it, and it goes.

As between air and electricity the relative claims are not so easily settled, and circumstances may sometimes cause the retention of both. The one which apparently refuses absolutely to be ignored or rejected is electricity. It must be had at least for lighting, and for long-distance transmission of power it has made the field its own. In many plants in these days it must be installed for these features alone, and if it could be also applied to the entire service in any particular plant, instead of employing also one or both of its chief competitors, that would be real independence for the proprietor.

For the driving of rock drills and allied reciprocating apparatus, especially the channeler for quarry work and radial coal cutter, which also is a channeler, air has, up to quite recently, monopolized the job. All at once comes along the electric-air device, which, by an adroit mechanical compromise, entirely changes the situation and makes the electric current fully competent for the lost employment in mine or quarry which compressed air has claimed as exclusively its own. It is the independence which the electric-air device gives as to choice of motive power which constitutes its supreme excellence. It emancipates the employer as completely as may be from the tyranny of his servants and he may now make his arrangements with the one instead of the three. The electric-air drill or channeler radialaxe coal cutter may still call itself an air-operated tool if it will, but only a wire connects it with the power-house.

# "ELECTRIC-AIR RADIALAXE"



For the electrically equipped coal mine there is the "Electric-Air Radialaxe," adapted for shearing, entry driving, cutting out bands, mining in mid-seam, or undercutting on a pitch—all done by electric power at the least cost in the shortest time.

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### Steam Hammers

WHEN the steam hammer was first devised in order to replace the old-time helve trip hammer, steam machinery had not nearly attained its modern degree of efficiency, and the idea of securing any high economy in the use of steam in the hammer was not considered, the real demand for the machine appearing in the necessity of handling larger work than could otherwise be done. Gradually the work of the steam engineer improved the performance of the steam engine, and to-day the efficiency of the use of steam in the production of power appears to have almost reached the limit possible under the conditions of operation.

With the steam hammer, however, the development has been different, and only in certain cases has the same care been given to the attainment of efficiency, the builder and user often being contented if capacity and reliability were secured. Nevertheless, it must be remembered that the steam hammer is really a machine tool, intended for the economical and advantageous production of parts of other machines, and there should be brought to its design and construction the same care and skill as is given to lathe, planer, or engine. Its efficiency depends, not only upon the size and kind of work which can be handled, but also upon the cost of its operation, the convenience with which the operator can handle the product, and the freedom from delays incident to breakdown, wear and other defects.

In order that the steam hammer may become the efficient machine demanded by the requirements of modern economical production, it must be designed and built in the same careful manner as other high-grade machine tools. This means that the latest resources of the engineer are to be drawn upon, using modern alloy steels for the parts sustaining the largest stresses and briefest shocks, and proportioning the parts with correct determination of the forces which they have to resist.

Proper design, however, should cover, not only the scientific proportions of the machine, but the operative details as well. The control, upon which prompt and safe operation depends, requires easy and smooth valve gear, free from concussion due to the working blows of the machine, and capable of easy handling by the operator. Efficient operation is also dependent to a very large extent upon the facility with which the work can be manipulated, and the design of the frame and arrangement of anvil may contribute materially to the avoidance of unnecessary and useless motions.

A large part of the high economy which has been attained in the modern steam engine is due to the systematic testing which is given to each type of machine, and to each engine itself. Losses must be detected and investigated before they can be remedied, and it is only by a critical test of a finished machine that its actual performance may be determined. The relation of the work which goes in, to the work which comes out, is the measure of efficiency, and the same system of testing which has done so much to aid in the perfection of the steam engine has been successfully applied to the steam hammer; so that, from a rather crude auxiliary to the smith shop, the modern steam hammer has been developed into a skillfully organized machine tool, fully equal in design and construction to its associates elsewhere in the works.

It is becoming more and more appreciated by engineers and manufacturers, that the most important element in the attainment of high productive efficiency is the use of power-operated machines wherever possible, the efficiency of these tools being capable of high development, and their operation kept in the hands of a few skilled operatives.

# Designed, Built and Tested Like a Steam Engine

# BEMENT HAMMERS

Offer Exceptionally High Efficiency Ratio of Horse Power Output to Horse Power Input. Equipped with Forged Steel Rams, Cast Steel Dies and Nickel Steel Piston Rods, Forged in One Piece.

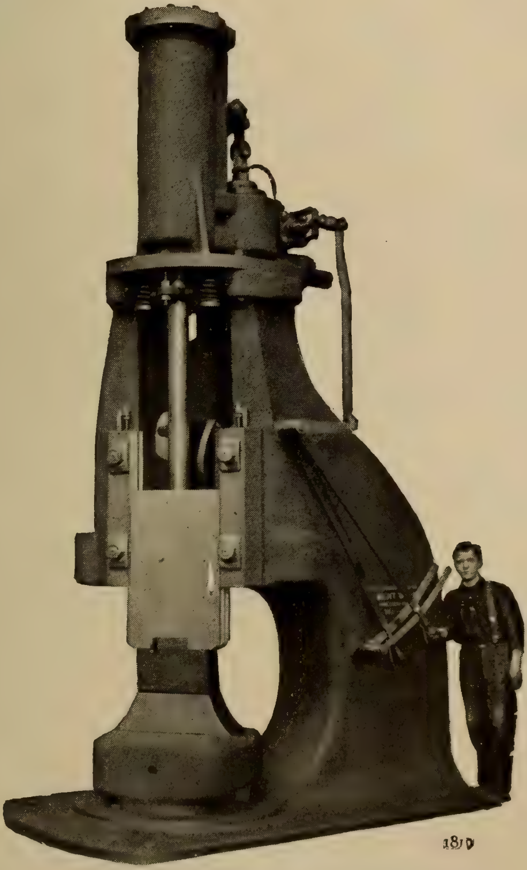
Cylinder and Frame Built of Sound Castings of Massive Dimensions.

Main Valve is of the Piston Type and balanced.

The Valve Gear has no connection with Ram, thus escapes all concussion.

Guides are adjustable to permit the natural wear to be readily taken up, and are of a different carbon steel to prevent cutting by ram.

Anvil is protected by a Cap, which is dovetailed to the lower die. Since using this construction not a single anvil has been broken. To replace anvil it is necessary to lift hammer off its foundation.



**3,300-lb. Bement Single-Frame Steam Hammer**

**Built in a Variety of Sizes and Types**

**Write for Catalog "Bement Hammers"**

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ITALY, Ing., Ercole Vaghi, Milan. JAPAN, F. W. Horne 70-C, Yokohama.
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### The Age of Better Steel

RECENT years in engineering have sometimes been considered as forming the "age of steel," and the name is not inappropriate when it is considered how extensively iron and timber, as materials of construction of the past, have been superseded by that remarkable combination of iron and carbon known as "steel." Rails or girders of wrought iron are now difficult to obtain in the market, wrought-iron pipe is replaced by steel pipe, and grades of steel ranging from the mildest boiler plate to the hardest cutting tool may be obtained for almost every purpose.

All this change and development has been in response to the demand of the engineer for better material, a demand which is apparently never satisfied, but which continually presses the chemist and metallurgist for new products to meet new purposes.

These demands are made by the engineer, not because of any mere desire to exceed previous requirements, but in consequence of the increasing magnitude of the problems which he has to solve.

From the railway comes the demand for heavier, swifter, and more powerful locomotives, these, in turn, compelling stronger bridges and tougher and stronger rails. The transatlantic steamship lines are continually ordering larger and swifter steamers, and to-day the thousand-foot liner is almost in sight. The whole new industry of automobile building is calling out for material which will provide a minimum of weight and a maximum of strength, stiffness and toughness; while the still newer art of constructing aeroplanes which shall be effective on a commercial basis is making still more insistent demands and more stringent requirements. When to these special fields of application we add the great department of building construction it will be seen that we are not only in the age of steel, but entering upon a period in which better and better steel will enter into the products of the engineer and manufacturer.

Just about the time when the resources of the metallurgist to improve steel composed solely of iron and carbon seemed to have become exhausted it began to be realized that there might be other substances besides carbon which could be utilized in steel development. Substances which, in the older treatises on chemistry, were classified among the "rare" elements, such as molybdenum, tungsten, vanadium, titanium, and the like, were found to impart curious properties to steel, when scientifically applied, opened up a wide field for the production of materials far superior to that which had hitherto been considered possible.

The result was the production of what are termed "ferro" alloys, combinations of iron with various special elements, elements which were found not to be so rare after all, and these ferro alloys, when added to carbon steel, iron or other more common materials, enabled the foundryman to reproduce on a commercial scale new materials formerly known only in the chemical laboratory. Of these alloys one of the most interesting is ferro-vanadium, a combination, in predetermined proportions, of iron and vanadium, free from carbon, and thus ready to be added to the material in the crucible or furnace, and produce a vanadium steel of the highest degree of strength, toughness and freedom from crystallization.

The extent to which vanadium steel is helping to usher in the age of better steel is seen in the manner in which it is used in the construction of locomotives, automobiles and general machinery. Its use in the manufacture of springs, gear wheels, pinions, locomotive frames, axles, bridge members and cutting tools has contributed largely to the development of the manufacturing industries and to the improvement in efficiency of production, which is the aim of every enterprising manufacturer at the present time.

# The AIM of the AGE
# BETTER STEEL

Without better steel we cannot have

**Swifter Locomotives,**
**Safer Automobiles,**
**More Durable Rails,**
**Higher Buildings,**
**Faster Steamships,**
**Successful, Practical Aeroplanes,**
**Lighter Bridges or**
**Better Tools.**

Progress is measured by the speed of our Locomotives, the safety of our means of Transportation, the positive, dependable service of our Machinery, the excellence of our Tools.

Every improvement in the quality of steel advances Civilization.

VANADIUM, added to all kinds of steel as Ferro-Vanadium, makes the fundamental improvements in the metal by which strength, toughness and freedom from crystallization are secured.

And mark this: That strength plus toughness plus freedom from crystallization equals, in steel, the standard sought by all manufacturers of "quality" products.

There is no question about the Vanadium factor in steel. Years of experiment, laboratory tests by experts in America and Europe, and actual results in the most drastic service, have proved that Vanadium is "The Master Alloy."

We are prepared to deliver "Amervan" or "Masvan" Ferro-Vanadium in any quantities, promptly, free from Carbon, certain in analysis, ready for use in any Foundry, Crucible or Open Hearth Furnace. Full directions and recommendations furnished, together with adequate literature on Vanadium, on request,

VANADIUM "AMERVAN" CARBON MANGANESE SILICON NICKEL CHROMIUM IT HOLDS THEM ALL TOGETHER

VANADIUM "MASVAN" CARBON MANGANESE SILICON NICKEL CHROMIUM IT HOLDS THEM ALL TOGETHER

## American Vanadium Company

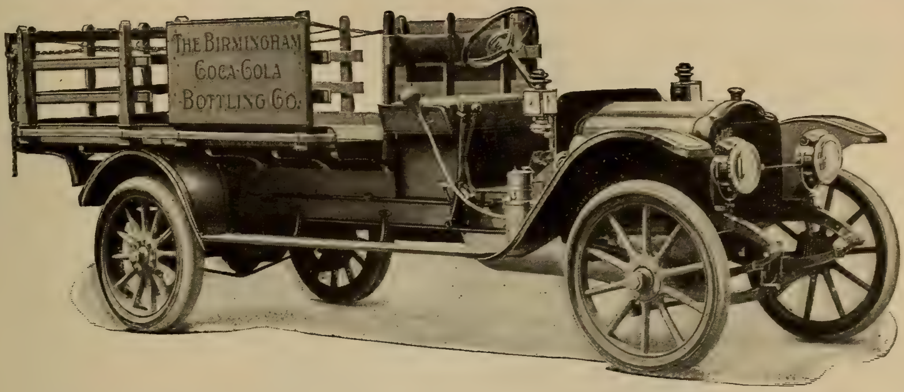
**335 Frick Building** **PITTSBURGH, PA.**

### The Problem of Distribution

ONE of the great difficulties of modern city business is due to the increasingly crowded streets through which people and vehicles must make their way and conduct their interchanges. This matter is generally conceded to be one of the most important problems of the day, the question of distribution. Especially is it difficult because nearly every method devised for its solution also acts to create further crowding and make additional obstruction. Nevertheless it is necessary to do something to provide for the demand in a better way than has been employed for so many years past and to furnish something better than the mass of slow-moving horse-drawn teams which are no longer equal to the tremendous task.

The distribution and delivery of merchandise to all parts of a great city is one of the few departments of work which has not yet been systematically and scientifically undertaken by machinery. In nearly every other line of work the rapid growth of modern times has been met by the production of mechanical devices to enable the increase to be handled. The railway has replaced the team on the highway and the steamship has supplanted the sailing vessel on the sea. On the great fields of the West the reaping and binding machines have made possible the harvests which would have been impossible to unaided human effort, while grain elevators and conveyors have made the terminal handling practicable. Nevertheless, all these great additions to the transportation possibilities of the country have been developed without any comparable advance in the apparatus of distribution of the merchandise at the points where railway, steamship and warehouse leave off. One has only to look at the congested yards of the railroad terminals, or the long lines of teams waiting at the docks of the ocean steamship lines to perceive the incongruous association of the most modern transportation appliances endeavoring to make connections with the most primitive apparatus for distribution.

There is, however, in sight at the present time some indication of relief in the solution of the distribution problem, since the mechanically-propelled vehicle is being developed to take the place of the ancient use of animals. The motor truck and the delivery wagon have already been sufficiently developed to enable their value in this important field to be demonstrated. Even during the past few years there has been seen a widely extending use of such power-driven vehicles to do the work which was previously performed by heavy teams of horses, and the increased capacity and speed possible have enabled considerable relief to be attained. There is, however, much yet to be done before the distribution portion of commercial transport catches up with the equipment already in operation for long-distance conveyance. The possibilities of the motor truck are unlimited, but the work to be done may also be said to be unlimited. The locomotive has its own right of way upon tracks controlled solely for its use, while the steamship has the freedom of the ocean lanes, but the motor truck has yet to find its way through city streets crowded with slower vehicles of other kinds, and used also by pedestrians having the rights inherited from earlier times and far different conditions. Doubtless these difficulties will remedy themselves as the pressure for relief becomes more and more insistent. The vehicles of the older type will disappear in the course of time, and the segregation of foot and vehicular traffic must follow, if the full usefulness of the motor vehicle is to be achieved. In any case, complete efficiency in the transport of merchandise cannot be effected until a fairly complete co-ordination of all the elements of the service is brought about; until the mechanism of distribution is brought up to the completeness and effectiveness of the mechanism of long-distance transportation.



# Possibilities of Motor-Trucks Unlimited

THERE is practically no limit to the possibilities of motor-trucks in the business world. Every man who has a cartage problem is anxious to know just how motor-trucks will work out under his conditions. But the question is solved—The White Company have hundreds of trucks in operation in almost every conceivable kind of business—under practically every known condition—and there is not a single owner to whom we could not refer a prospective buyer. Not one has been disappointed, but on the contrary each has found that the White truck has exceeded his expectations.

**Increased Service** White trucks serve their owners, first of all, by increasing the service. They make it possible to do things you have never done before—to secure trade you were unable to reach—to be prompt where you were compelled to be dilatory before—to increase your service and thereby increase your business.

**Increased Economy** Under the majority of conditions, White trucks increase the economy of your delivery—not always—there are conditions where trucks only increase the service. The truck replaces two or three teams—is not as expensive to maintain as two teams and requires no more men to operate than one team, saving salaries.

## White Trucks—The Solution

White trucks solve your delivery problem, by increasing your service or increasing the economy of your service, or both, because they are well designed for economy's sake, having the long-stroke, medium-bore engine, which is powerful but economical. They are built for economy's sake because we use the best materials modern science has produced—the special alloys of steel, heat-treated, that are best suited to the various purposes to which they are put. White trucks are made in three sizes, with engine standardized in all types, to simplify the mechanical problem, and make White Trucks adaptable to any business, any special or unusual requirements.

Let us submit a solution of your delivery problem, with catalogue and testimonials of the world's largest users.

**The White Company**

832 East 79th Street, Cleveland

## Detroit Steel Products

WHEN, in England, in 1851, it was determined to hold the first of the great international exhibitions, there was much discussion about the plans for the building in which the great display was to be made. Finally the design of Mr. Joseph Paxton was adopted, because it provided for a structure composed almost wholly of iron and glass, furnishing at the same time strength and daylight illumination. Many people thought at that time that the "Crystal Palace," as it was called, was in itself the best exhibit of the whole affair, and the building was so much admired that after the period of the exhibition was over the structure was removed from Hyde Park and re-erected at Sydenham, near London, where it now stands.

The methods of construction available at that date and for a long period after were such that the combination of glass and metal was not available for general purposes, and no more crystal palaces were built. During the past few years, however, the subject has been taken up by capable engineers, who have realized the immense advantages which the flood of daylight admitted to such a building would provide. The result has been the appearance of steel windows as a commercial product, enabling manufacturing buildings to be constructed of ample strength and with a minimum of obstruction to the entrance of light. The Crystal Palace of London has remained solitary and unique, but the crystal workshop is becoming the accepted order of construction for the factory.

Any one who remembers the old-time workshop will recall the dingy windows, with small panes, heavy frames, and continual condition of grime. The idea that ample daylight was one of the most important elements in the attainment of high efficiency in the workmen, acting both to the production of accurate work and the maintenance of good health, was not understood. Even had it been appreciated, the methods of building construction available would not have permitted the removal of a large part of the wall and the substitution of weak wooden frames and sash. It required the development of a complete system of design and construction to make the steel window a commercial proposition, involving both invention and scientific proportioning, to enable the idea to become practicable. In the ordinary window the joints are the weakest parts; in the modern steel window the joints are as strong, if not stronger, than the balance of the structure. Combustible material is eliminated, light is admitted, and the entire question of building design reopened by the introduction of a new system of construction.

One of the interesting developments of the matter appears in the change in the entire method of planning a manufacturing building. Instead of considering arrangement of walls upon the old plan the engineer examines first the character of work to be conducted in the structure. The distribution of light and air is first determined and the steel-window portions of the building placed to give the desired results. A science of illumination of manufacturing buildings by daylight has grown up, leading directly to better sanitary methods, prolongation of eyesight, greater productiveness of more accurate work, and general higher efficiency, simply by letting in the natural light which has never yet been equaled by any artificial product.

Many specialists have studied and worked over the problem of the best methods of providing artificial illumination for workshops, but the true solution of the problem has appeared in the simple one of letting in the clear light of day, which costs nothing and is only awaiting utilization.

The Strength and Efficiency of Fenestra Joint is greater than any sash now on the market. Strength is added, not lost, at point of intersection.

**Detroit-Fenestra**

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**Solid Steel Windows**

please your clients because of the business prestige they carry; because they peak success; and they mean success because of the fire-proof construction the saving in lighting bills, and the doubled efficiency of the working force. Specify Fenestra, and let Fenestra experts assist with your plans of lighting and ventilation.

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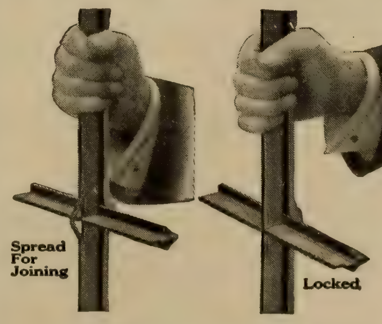
**DETROIT STEEL PRODUCTS CO.** Dept. 26 **Detroit, Mich.**

**The "Fenestra" Joint**



**Practically No Metal Lost**

# FINANCIAL NOTES

**A department of information on industrial and other securities of value to investors and men of affairs.**

OF THE
## INDUSTRIAL WORLD

**SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible, the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.**

**CHARLES EASTON, Financial Editor.**

### The Situation

THE general trend of events governing important business interests continue in about the same direction as was indicated last month. The country's business is now and has long been undergoing readjustment, and it is conceded by thoughtful men that the sooner this readjustment is completed and business men are permitted to progress without fear of political interference the earlier will the country re-embark upon a prosperous career.

What industry is in need of is not governmental machinery to fix prices, but the enunciation and enforcement of a few clear principles, and, as Secretary Nagel says, "to define their legality, and to provide a form into which any industry might be cast without a suit or a decree."

It is pleasing to note the decided resentment on the part of the public to the incessant nagging of petty politicians. Corporations certainly need reforming, but it is an open question which is the most corrupt, the corporations or the methods employed by some people to reform them.

General business continues to move slowly and cautiously. The wonder is that the volume is as large as it is, in view of the general lack of confidence. The fact that business conditions have improved in the face of serious obstacles is an encouraging sign and justifies a hopeful view as to the future.

There has been no wild speculation in stocks or bonds. Securities are widely distributed in the hands of real owners. Financial interests have almost completely withdrawn from active participation in the stock market.

The small investor has not been in the market for a long period and the large commission houses have just begun to realize that the small investor has "reformed." He no longer takes the gamble he once did on marginal trades, but buys in small lots and pays cash, which is commendable.

There is not a citizen in the country, no matter how humble, who is not affected by the condition of the stock market. We frequently hear expressions to the contrary, and because of this false belief the public is too apt to join in acts which inevitably prove disastrous, as the present indiscriminate attack on corporations is doing. However, making allowance for all the unfortunate happenings, the outlook is encouraging.

*Question*—What do you think of St. Louis and San Francisco common?

*Answer*—The common stock of this company is an issue which is essentially speculative in character, never having returned anything to the holders in the way of dividends, with little possibility of any such reimbursement in the near future. However, the working out of the plans which the present management has drawn up should improve the company's position as to earning ability.

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It is stated that recent inquiries by railway companies point to the early ordering of some 14,000 cars of various kinds from the builders of the country. This may be considered a favorable omen.

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*Question*—What dividends have been paid by American Can Preferred?

*Answer*—American Can Preferred is a 7 per cent. preferred stock, on which 5 per cent. per annum has been distributed since 1903. To date 31 per cent. deferred dividends have accumulated, which must eventually be provided for in one way or another.

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Both the Missouri Pacific and Iron Mountain have recently made an unexpected showing of earnings, both gross and net. President Bush seems to be starting off well. Much is expected of him in connection with these great properties, and there is much for him to do.

---

*Question*—Is there a possibility of dividend payments on Colorado Fuel and Iron preferred stock?

*Answer*—Brokers acting for unknown principals have been quietly gathering up the preferred stock of this company for months, and it is possible that some payment may be made on account of the accumulation

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We will finance a home for you according to your own plan on attractive building site within a few moments' walk of Tuckahoe and Bronxville stations, the highest and most picturesque section of Westchester County, New York, 30 minutes from Grand Central Station, New York, N. Y.

*Write for particulars*

**Debenture Corporation of New York**
**334 Fifth Avenue, New York**

**The Delaware and Hudson Company**

NOTICE TO MANUFACTURERS

This railroad extends from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines; provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, now being built by the state, connecting the Hudson River with Lake Champlain. An establishment located in this territory receives the benefit of cheap fuel, electric power and low freight rates.
Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

IRA H. SHOEMAKER
ALBANY, N. Y. Industrial Agent

of more than 60 per cent. of dividends to its credit.

---

The University of Wisconsin is authority for the statement that in the United States some ten billions of dollars is spent annually for food, shelter and clothing, and that 90 per cent. of this is spent by women, who have no adequate knowledge of values.

---

*Question*—What is the financial condition of The Debenture Corporation of New York, and under the laws of what State is it organized?

*Answer*—The Debenture Corporation of New York is organized under the laws of the State of New York, with full paid capital of $100,000. On January 1, 1911, it showed assets of $342,000 and a surplus of $75,000, as attested by The Audit Company of New York. It is doing a splendid business and is favorably regarded.

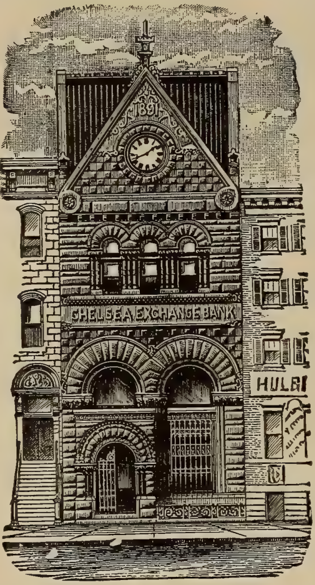
---

President Brown, of The National Railways of Mexico, states that the railways of the republic are now carrying more traffic than a year ago, and that business has not suffered as much from the recent war as had been supposed. By choosing the quiet season before summer planting for their campaign the revolutionists caused the least possible loss to agriculture.

---

*Question*—How do you rank the stocks of the Pacific Telephone and Telegraph as an investment?

*Answer*—Pacific Telephone and Telegraph preferred is a 6 per cent. accumulative issue, which has received its dividends regularly. The stock is listed upon the New York Stock Exchange, but it is not especially active. At current levels the stock yields a trifle more than 6 per cent. A common stock has never paid a dividend, but there is considerable speculation in it. How soon the directors will see fit to give the



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**NEW YORK, N.Y.**

**Capital - - - $200,000.00**
**Surplus and Undivided Profits $196,000.00**

**Depositary for the State and City of New York**

**Prompt remittances made on all drafts sent us for collection.**

**SAFE DEPOSIT VAULTS**
**Boxes $5.00 per year up**

*We are located just a stone's throw West of the 34th Street entrance of the new Pennsylvania station, making it very convenient for the transaction of your banking business.*

*Your account is solicited.*

**Officers**

Irving M. Shaw, President
A. E. Stilger, Vice-President and Cashier
Wm. A. Lobb, Assistant Cashier
Wm. W. Tappan, Assistant Cashier

junior issue consideration in the matter of dividends furnishes the peg on which its speculative possibilities hang.

---

The United States Steel Corporation reports unfilled tonnage orders on July 31, 1911, at 3,584,085 tons. The unfilled business on the books of the Steel Corporation as of July 31 shows an increase of approximately 223,000 tons, which was generally looked for by the trade. At present the Steel Corporation is operating about 80 per cent. of its ingot capacity. The present rate of operation means the ingot output of nearly 14,500,000 tons a year.

---

*Question*—What do you think of Interborough Metropolitan 4½ bonds and Missouri Pacific convertible 5's? Are they a good speculative investment?

*Answer*—Interborough Metropolitan 4½ per cent. bonds are a better speculative investment than the convertible Missouri Pacific 5's. There is no likelihood that the companies will ever be unable to pay their interest.

---

Chicago & Eastern Illinois Railroad directors have declared a cash dividend of 5 per cent. on all the outstanding capital stock (common and preferred) of the Evansville & Terre Haute Railroad Company, payable September 1. This is the same rate as was paid in 1910. This declaration represents the adjustment of dividends in connection with the absorption of the company by the Chicago & Eastern Illinois Railroad Company. Only a small amount of the Evansville stocks are outstanding.

---

*Question*—Will the recent sale of $1,000,000 bonds by the Corn Products Refining Company improve the value of the common stock?

*Answer*—Yes, because it gives the company additional working capital, which, if properly used, should increase its profits.

**6% For Your Surplus**
**6% For Your Savings**

Our plan in issuing 6% Gold Bonds, that are secured by New York Real Estate, enables investors of moderate means, or those who desire to start a savings account, to secure a gilt-edged investment.

The principal is absolutely safe and the interest certain to be paid as it becomes due.

The bonds are sold at par, bear 6% interest, which is payable quarterly, and mature in ten years.

You can purchase them for all cash or take twenty months in which to pay for them. In either case your investment earns the 6% on whatever amount you have paid in.

They are issued in denominations of $100, $500, and $1,000.

Let us mail complete details to you without obligation on your part. Write

**Debenture Corporation of New York**
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Business confined strictly to New York Real Estate. We do not deal in miscellaneous securities.

**NATIONAL DEFENSE**
"MILLIONS *for* DEFENSE, *But not a* CENT *for* TRIBUTE."
"*In* TIME *of* PEACE PREPARE AGAINST WAR."
A JOURNAL FOR PATRIOTIC AMERICAN CITIZENS

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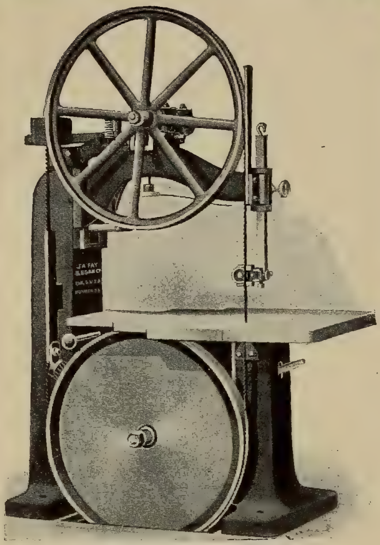
COLUMBUS, OHIO



No. 58—Band Scroll Saw

**BAND SAWS**

**30-33-36 or 42 in. Wheels**

**Patented Feb. 27th, 1900**

We will sell you a band saw of either of the above sizes, guaranteeing it to be better in every respect — a machine which will turn out finer work and more of it with less power than any other make of the same size.

The machine illustrated herewith is especially designed for all kinds of plain and intricate scroll sawing, making it especially adapted for pattern and car shops.

Our special band saw catalog, sent free upon request, gives full details of the construction. Write for it.

**J. A. FAY & EGAN CO.**
**226-246 W. Front Street**
**CINCINNATI, - - OHIO**

The New York Edison Company has for several years maintained a free technical school for its employees. Other large corporations of similar character would do well to emulate this policy. Such consideration on the part of large institutions for its employees will tend to create a better feeling and incidentally produce greater efficiency among the men.

---

*Question*—What is the assessed value of New York City real estate for 1911?

*Answer*—The assessed value of New York City real estate for the current year is $7,858,840,164, an increase of $800,000,000 over 1910.

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It is believed that within the next five years the subway lines of Greater New York will be carrying 800,000,000 passengers per year.

---

*Question*—What do you think of the copper situation?

*Answer*—The copper situation may be described as fairly good. The world's stock of copper is being reduced at the rate of 10,000,000 pounds per month. While prices are low, yet the consumption abroad is enormous. The consumption in America is not normal. It seems true that the consumption of copper runs parallel to that of steel. When steel resumes its normal condition, copper consumption in America will be largely augmented, and we shall have better prices.

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Mr. Thomas A. Edison once said that his net returns from incandescent lamps aggregated about $3,000,000. He added, however, "that the people had the majority of the wealth which was in his lamps." Mr. Edison gave some statistics, which had been collected for him, showing that the total capitalization of corporations engaged in the manufacture of electric lamps or the marketing of the lights was approximately $300,000,000. The stock is held by several thousand people. The industry gives employment to some 200,000 persons, most of them skilled artisans.

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The depressed condition of our textile industries is largely the natural reaction from the boom which preceded, and what is especially needed now is lower costs of raw materials to offset the decline in the prices of finished goods. Fortunately, the prices of raw materials seem to be moving in the right direction.

There is some gossip in steel trade circles that the price of certain commodities may experience a readjustment in the near future, although nothing definite in this respect has taken place as yet. Steel prices at the present time are lower than they have been in months past.

Wire, which underwent a cut last June, is in good demand at present quotations, and a further cut would seem incredible.

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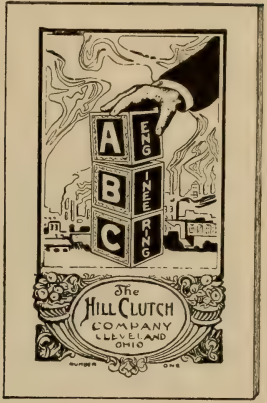
An interesting fact has just been made known to the effect that in ten years' time the number of shareholders in 219 companies increased from 218,000 in 1901 to 821,000 in 1911. In our judgment this unusual increase in the number of shareholders in these companies is traceable directly to the small investor buying his securities outright instead of on a margin, thus having his name enrolled upon the stock books of corporations.

We believe that the gradual accumulation of seasoned securities by the great middle class of American people will eventually serve as an invaluable balance wheel for large corporations.

---

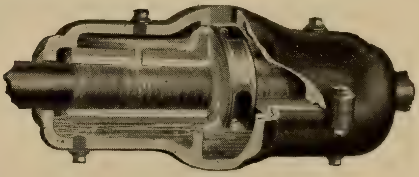
### A Car Shop Necessity

There is probably no machine more essential in the car-building shop than the mortising machine. For many years this work was done by machines of the pounding type, but since the development of the hollow-chisel type of machine this latter form has



This Booklet Will Show You How to Reduce Your Friction Load

If you tried to run your shafting and machinery without oiling the bearings, you know that the friction load would be more than your power equipment could handle. If your oiling facilities are inadequate, you know your overhead expense is too high. Then you certainly know that if your bearings run in a *bath* of oil, you are operating your transmission at a minimum expense. The most practical—the most economical bearing—is the



**Hill Collar Oiling Bearing**

As the illustration shows, a thrust collar is clamped to the center of the shaft in the center of the bearing, which elevates the oil to top reservoirs. The oil then flows by gravity over the shaft, flooding it continuously with a film of lubricant that eliminates all possible friction and danger of heating. This bearing does not depend on capillary action as the ring type of bearing does, and when the machinery is started, after lying idle for a time, thorough lubrication is commenced at once. No matter what the conditions or how hard the service, Hill Collar Oiling Bearings are always ready, always working. They save babbitt, oil, shafting and machinery—save time and shut-down trouble and *they save you money.*

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Boston Society of Civil Engineers.

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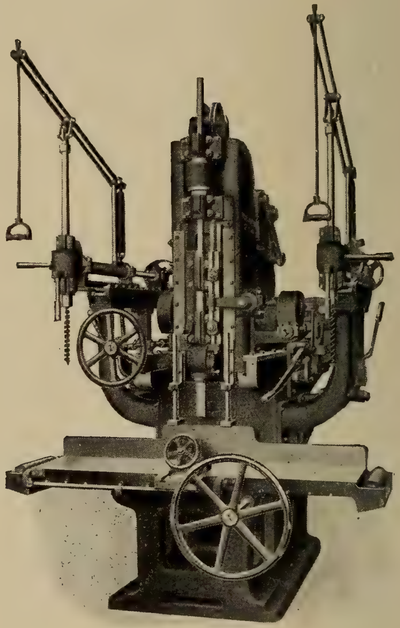
been specified almost exclusively by the modern railway shop.

The hollow-chisel machine has the great advantage of the elimination of all pounding and jarring, thus insuring greater accuracy, clean mortises and saving of time formerly required for the removal of chips.

For freight car work the Fay & Egan No. 214 vertical hollow-chisel mortising machine is frequently specified, and the construction is clearly shown in the accompanying illustration. This is undoubtedly one of the most powerful woodworking tools ever designed. Like all the other Fay & Egan tools it represents high efficiency in every sense of the word. All the controls for adjustment and operation are within easy reach of the operator, the arrangement permitting the handling of the stock in the quickest and most economical manner. Auxiliary boring attachments may be provided with this machine, as shown in the illustration, these being furnished or not as or-



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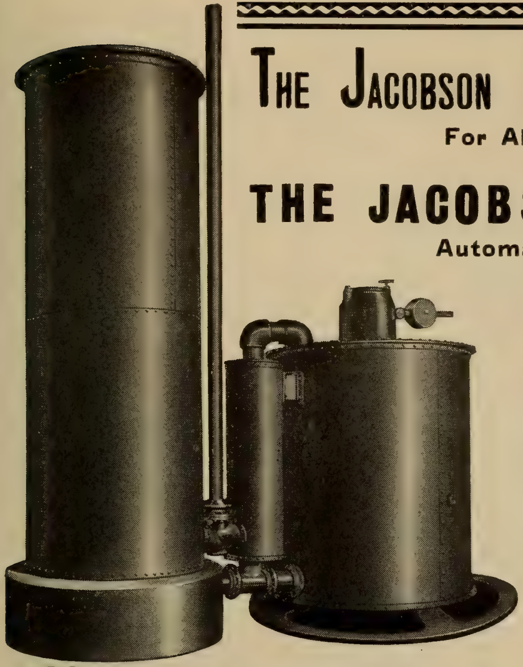

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dered. A fuller detailed description of the machine may be obtained by referring to pages 138 and 139 of the Fay & Egan catalogue, and additional information may be obtained by communicating with the Fay & Egan Company, 226-246 West Front street, Cincinnati, Ohio.

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### The "Santo-Duplex" One-Sweeper Stationary Vacuum Cleaner

THE accompanying illustration affords a clear idea of the general construction of the Santo-Duplex diaphragm vacuum cleaner offered by the Keller Manufacturing Company, of Philadelphia, Pa.

It will be seen that it consists of three parts: Base, middle or operating portion, and upper or dust receptacle chamber.

The base is a round, conical casting, 23 inches in diameter. This affords sufficient spread and weight to give the machine a firm bearing, and at the same time avoids the necessity of special foundation. In other words, the machine can be set on any level floor, and in many cases does not even require screws or bolts to hold it down, for the simple reason that it is entirely self-contained and the working parts are arranged in vertical line and balanced in such a way that the machine is absolutely steady and smooth running.

In the illustration shown, the steel casing which encloses all of the operating parts is broken away so that the general details of construction can be clearly seen. It will be noticed that the operating part consists of a lower pump chamber, above which is supported a similar chamber by means of four tubular columns, which, at the same time, serve as a passage way for the air from the vacuum chamber to the lower pump.

Supported centrally between these two pump chambers on a substantial bracket or bridge is a ¼-horse-power motor, designed especially for this machine.

The motor shaft is ⅝ inch in diameter, extended beyond each bear-

**The Santo-Duplex**

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| Electric Power Plants | 938 |
| Electrical Supply Dealers | 672 |
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| Flour and Grist Mills | 2801 |
| Furniture Mfrs. | 470 |
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| Ice and Refrigerating Plants | 949 |
| Knitting Mills | 182 |
| Machine Shops and Foundries | 1286 |
| Mill Supply and Machinery Dealers | 461 |
| Mines and Quarries | 1466 |
| Phosphate Mines & Fertilizer Mfrs. | 459 |
| Planing Mills | 2034 |
| Plumbers and Steam Fitters | 1829 |
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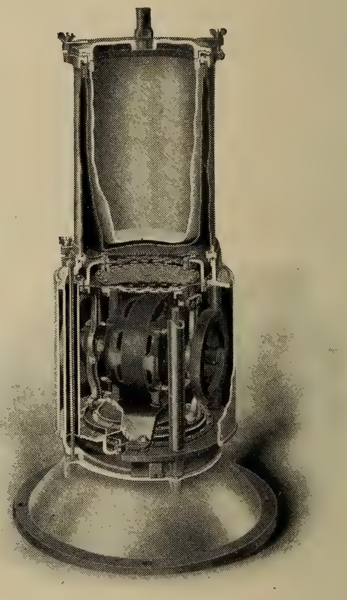
ing and carries on each end a double eccentric, which is machined from a single piece and heavily keyed to the shaft.

Surrounding the eccentrics are the necessary steel ball-bearing races and aluminum connecting rods, two of which connect with the moving portion of the upper pump and two with the moving portion of the lower pump.

From the cut it will be seen that there are only three moving parts in the entire machine: The armature or rotor of the motor with the two eccentrics and the moving portion of the upper and lower pumps.

The eccentrics are 180 degs. apart and the movements of each pump member ⅝-inch. The speed of the motor is approximately 1,200 revolutions per minute, which gives 2,400 impulses per minute, and an absolutely constant suction.



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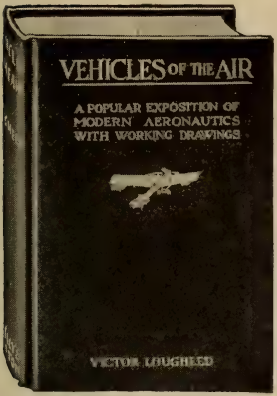
The motor bearings are bushed with bronze-bearing metal, and are unusually large in proportion, each bearing being provided with a grease cup of sufficient capacity to operate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the machine for several months without requiring attention. The ball-bearing eccentrics are of special construction, furnished by the Hess-Bright Manufacturing Company.

Each of the pumps is constructed upon the same principle as the regular Santo pump unit used in the Santo portable electric vacuum cleaner, and consists of a saucer-shaped chamber, which is closed by means of a leather diaphragm.

To the center of this diaphragm is secured a ring to which are attached the two connecting links used to operate the pump. The entire centre of the diaphragm is perforated with a series of ½-inch holes uniformly spaced, the perforated portion being covered by a galvanized steel plate, which has the same number and size holes as the diaphragm. These holes are so placed, however, that each one is covered by a solid portion of the plate. Above this is placed a galvanized wire netting, limiting the play of the diaphragm within the ring.

It will be seen that when the moving portion ascends air is free to pass through the holes in the plate and across and up through the holes in the diaphragm. However, on the reverse stroke the diaphragm closes down against the steel plate and each of the holes is tightly closed.

The number and size of these holes are so proportioned as to afford free and unrestricted passage of the air without loss due to back pressure.

Another advantage is that the central portion of the diaphragm covering the perforated steel plate is perfectly free and not rigidly connected with any of the moving parts. Hence, when the connecting rods and ring, which are positive in their motion, start to move either up or down, the inertia of the slack diaphragm in the centre of the ring tends to cause it to drag and this inertia automatically opens or closes the valve at the theoretically proper moment. The result of this is that the positive action of the pump begins on the instant of the reversal of motion, and consequently the volumetric efficiency of this form of pump is astonishingly high, and the slippage loss, which is customary in ordinary piston or rotary pumps, is reduced to practically a minimum.

The position of the eccentrics and the disposition of the cylinder in straight line is such that the two pumps are automatically balanced by the atmospheric pressure, and the wear on the motor bearings consequently reduced to a minimum.

The pump mechanism, aside from the ball-bearing eccentrics, has practically nothing to produce friction; therefore, the friction loss in the machine is hardly over 5 per cent. of the available motor power, whereas on machines which are operated by means of gears, chains or belts the friction loss often amounts to as much as 75 per cent. of the motor power.

It is for the above reasons that the Santo-Duplex with a ¼-horse-power motor can do practically the same cleaning work as machines using from a ¾ to 1-horse-power motor. This statement can be readily verified by tests of the volume of air handled and the vacuum in comparison with the same factors in other machines.

The dust chamber consists of a cylindrical steel shell mounted above the operating or pump portion and secured thereto by means of three thumbscrews engaging plugs at the lower ring. The whole dust chamber may be readily removed by loosening the three thumbscrews.

The dust chamber is closed by a metal lid fastened down by means of the same type of thumbscrew. This lid is made airtight by means of a rubber gasket effectually sealing the dust chamber and the lid.

The method of dust separation can be clearly seen on the enclosed cut. There are two bags—an interior bag made of tightly-woven cotton drilling, which is surrounded by a similar bag of firm and compact felt. The interior bag is the one which collects

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and contains the dirt and can be readily taken out by removing the lid.

This form of Santo separation is practically perfect, the heavy felt bag being used merely as a precaution to avoid the possibility of the dust being drawn into the pump should the operator replace the lid without returning the white dust rag.

The inlet to the machine through which the dust-laden air enters is shown at the top and centre of the lid. The connection between the piping through the house or building and the Duplex pump is made by means of a flexible rubber hose which affords direct connection with the piping, and preventing a transmission of any noise or vibration to the house by means of the piping, and also allows the lid of the machine to be removed without disturbing any connections.

The Santo-Duplex stands 40 inches high over all, weighs 180 pounds and has a capacity of 45 cubic feet of free air per minute with a vacuum of 8 to 9 inches mercury gauge.

Furnished with this machine is a complete set of cleaning attachments, enabling it to be used for nearly every cleaning purpose.

The installation of the plant is exceedingly simple, and owing to the small amount of current consumed by the motor, it can be attached to the ordinary lighting circuit and started or stopped by means of push button or snap switches without the necessity of extra heavy fuses or automatic starting devices.

Numerous patents have been awarded to the Keller Manufacturing Company on their Santo vacuum cleaners, and they are also licensed under the basic Kenney patents.

The Keller Manufacturing Company, of Philadelphia, Pa., will be pleased, upon request, to send copies of their catalogue describing the Santo-Duplex Stationary Vacuum Cleaning Equipment, showing its method of installation and operation.

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**Hydro-Electric Power**

The development of hydro-electric power from large and small streams, which, up to the present time, have not been thought of any value, is the subject of a publication issued under the title "Water-Powers of the Third Magnitude," by the American Spiral Pipe Works, of Chicago. A copy can be obtained by addressing Mr. A. J. Berger, P. O. Box 485, Chicago, and is well worth sending for.

**Direct Current Motors**

Direct current motors have been applied to the widest variety of industrial machinery. Their importance is now well established in practically every industry. The selection of the right kind of motor has, consequently, become a matter of very great importance.

A pamphlet recently published by the Crocker-Wheeler Company, of Ampere, N. J. (Bulletin 132), contains information regarding the design of one line of these machines that cannot fail to be of interest to anyone who uses power-driven machinery. The booklet is illustrated by half-tone illustrations of a variety of applications.

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By Parsell and Weed

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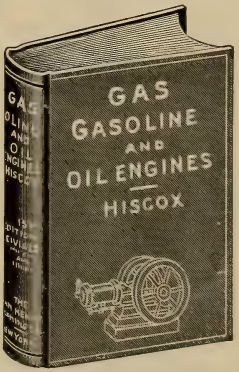

Every user of a gas engine needs this book. Simple, instructive, and right up-to-date. The only complete work on the subject. Tells all about the running and management of gas, gasoline and oil engines, as designed and manufactured in the United States. Explosive motors for stationary, marine and vehicle power are fully treated, together with illustrations of their parts and tabulated sizes, also their care and running are included. Electric ignition by induction coil and jump spark are fully explained and illustrated, including valuable information on the testing for economy and power and the erection of power plants. The rules and regulations of the Board of Fire Underwriters in regard to the installation and management of gasoline motors is given in full, suggesting the safe installation of explosive motor power. A list of United States Patents issued on gas, gasoline, and oil engines and their adjuncts from 1875 to date is included. Octavo. Twentieth edition, 484 pages. 410 engravings. Price ...................... **$2.50**

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Under the title, "An Essential of Scientific Management," the Smith Premier Typewriter Company has issued a little folder descriptive of the removable platen for use on their typewriters.

### Instruments of Precision

The Precision Instrument Company, Detroit, Mich., have just issued Bulletins G and H, the former treating of the new Roland Wild's calorimeter for estimating the heating value of solid fuels, the latter describing Carpenter's metropolitan Argand burner, copies of which can be obtained on request.

### Economy in Power Plants

Bulletin No. C187, issued by the B. F. Sturtevant Company, Hyde Park, Mass., contains a description of the efficient and economical power plant of the Wood worsted mills, together with a short section upon the apparatus responsible for the results and other interesting information secured by Mr. Geo. H. Diman, consulting engineer of the American Woolen Company, in his long years of experience.

The B. F. Sturtevant Company has for years been designing power-plant apparatus, and their engineerng organization is fully conversant with the requirements. Any firm contemplating building a new power plant, or who are not satisfied that they are securing best results from their present plant, may address the Sturtevant Company and have their engineering department go over the matter with them and make recommendations.

### Cement Sidewalk Paving

The sixth edition of an article by Mr. Albert Moyer, Assoc. A. S. C. E., entitled "Cement Sidewalk Paving," has recently been issued by the Vulcanite Portland Cement Company. The pamphlet is interesting, very fully illustrated, and contains much information of value to those who desire durable sidewalks, driveways and cement floors, for which "Vulcanite," which has been made under one management for the past fourteen years, has proved its worth. A copy of this book may be obtained by addressing the Vulcanite Portland Cement Company, Land Title Building, Philadelphia, or Fifth Avenue Building, New York.

### Should Terms of Payment be Enforced?

This is the title of a pamphlet by Mr. W. L. Brownell, treasurer of the Crocker-Wheeler Company, which is an address given before the Newark, N. J., branch of National Association of Credit Men. This address has already attracted the attention of credit men throughout the country, and will interest everyone responsible for the financial end of a business. A copy may be obtained by addressing the Crocker-Wheeler Company, Ampere, N. J.

### Electric Furnaces at the University of Illinois

There have recently been installed at the University of Illinois, through the combined efforts of the department of electrical engineering, the engineering experiment station and the department of chemistry, two electric furnaces. One of these is a Hoskins resistance furnace and the other a Colby induction furnace. Both are of 20 kilowatt capacity. The furnaces will be used for the purpose of studying the changes that can be brought about in the mechanical and physical characteristics of cast iron through the influence of the soaking process which it is possible to maintain.

Professor John M. Coulter, in charge of the Department of Botany of the University of Chicago, a distinguished scientist and an excellent speaker, gave an address before a joint meeting of the Sigma Xi and Phi Beta Kappa fraternities on Monday, June 12, as a part of the programme of Commencement Week at the University of Illinois.

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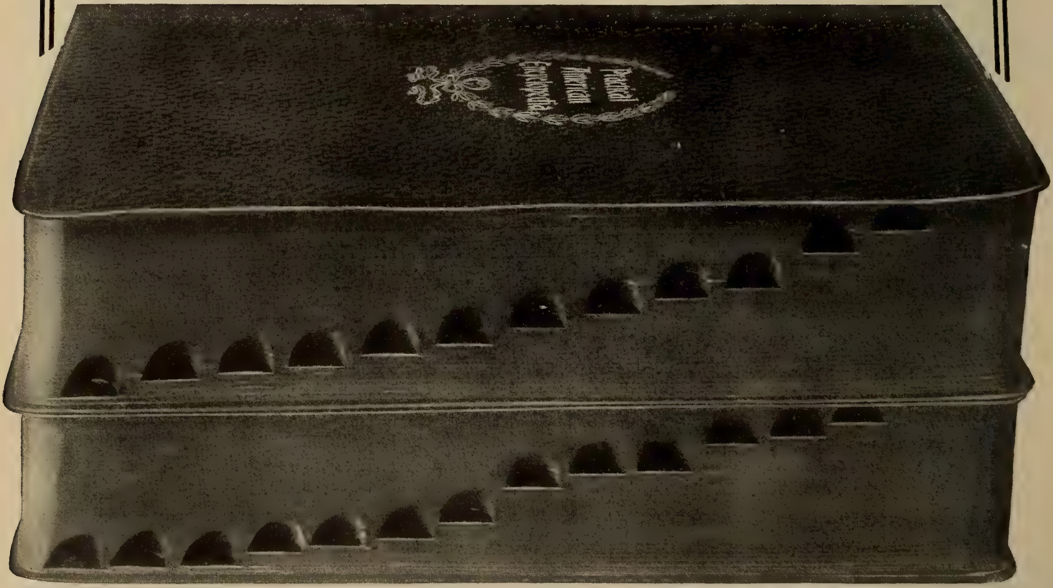
# PRACTICAL AMERICAN ENCYCLOPEDIA

THE BEST CONDENSED GENERAL REFERENCE WORK

Published April 10th, 1911



## The Practical American Encyclopedia

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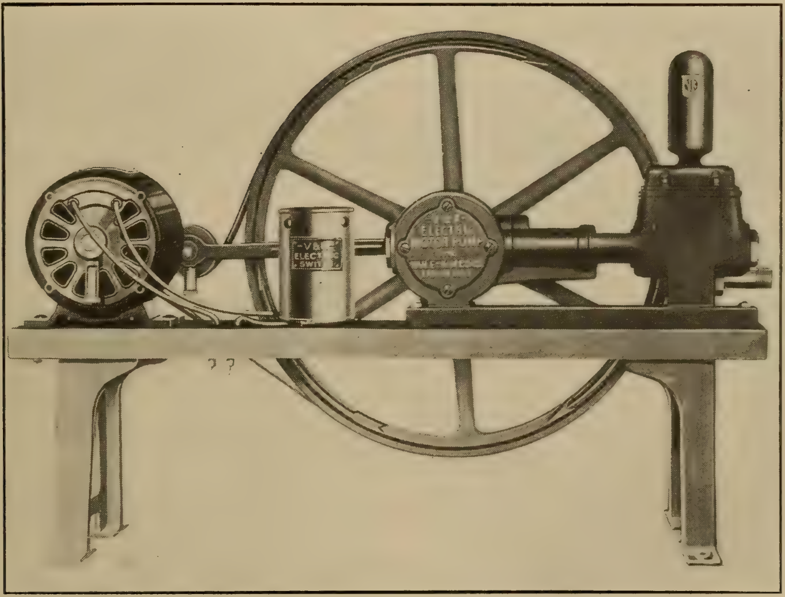
# A RELIABLE INDEPENDENT WATER SUPPLY

A MORE or less crude water system is one of the problems that confronts the property owner in rural and suburban districts and often proves a troublesome one to solve. The Vaile-Kimes Company, of Dayton, Ohio, are manufacturers of an electric motor pump which, when installed with a compression, or pneumatic tank, makes an independent reliable automatic water system for all purposes. It pumps the water direct from the cistern, well, lake or stream into a tank under pressure, and from there it is distributed to the house.



ELECTRIC MOTOR PUMP. THE VAILE-KIMES COMPANY

In cities where water rates are high or where the pressure is low, and where homes are supplied with electricity, the "V. and K." pump forms are efficient and inexpensive means of water supply. It is of sufficient capacity to furnish the average suburban home with water under pressure for bathrooms, kitchen, laundry and sprinkling purposes.

The power is obtained from a ⅛-horse-power Westinghouse small motor, used so extensively for the operation of small machines.

The first cost of this little outfit is comparatively small, considering its capacity and efficient operation. The operating expense is very slight, as the motor is so well designed and built that the cost of current consumed does not exceed 2 cents an hour.

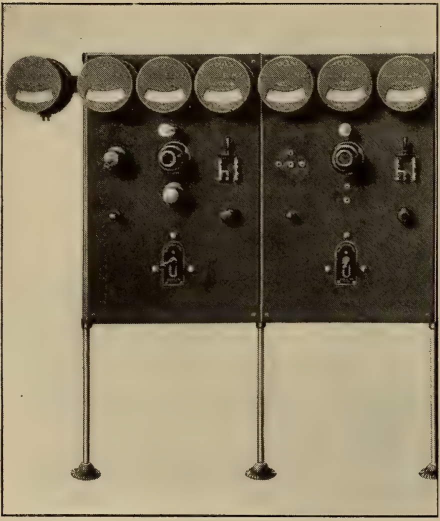
An automatic switch, governed by the water pressure in the system, controls the operation of the motor. This switch starts the motor automatically when the pressure falls to a given point and stops the motor when the maximum desired pressure is reached. No attention is therefore required to keep up the water supply. The pump

*Continued on page* 81.

## Alternating-Current Switchboards of Small Capacity

THE increasing demand for alternating-current switchboards of moderate capacity and price is shown by the popularity of the line of JB panels manufactured by the Westinghouse Electric and Manufacturing Company. This line has been extended to cover a wide range of switchboard applications, and is fully described in Catalogue No. 704, which has just been issued.

Type JB panels are particularly adapted for use in small central stations and isolated plants operating at voltages between 1,100 and 3,300.



JB PANELS, ALTERNATING-CURRENT SWITCHBOARDS OF SMALL CAPACITY

This type of switchboard embodies all the essential features required for satisfactory operation. Each panel consists of a black marine-finished marble slab, containing the controlling and indicating apparatus, which is mounted on a gas-pipe framework.

The framework is composed of two 1¼-inch gas-pipe uprights, each fitted with flanges for bolting to the floor and connected at the top by a continuous wrought-iron strap of 1⅜ inch by ½-inch cross section, which runs the full length of the switchboard framework. This construction insures perfect alignment of the panels and rigidity of structure. Pipe sockets for wall braces are supplied with the frame. The total height of the frame is 76⅜ inches.

The marble panels are 48 inches high, 1½ inches thick, with ⅜-inch bevel on the front edges. The width depends upon the amount of apparatus to be mounted upon the panel, and varies from 16 to 32 inches.

The finish of the marble is black marine, which is a dull, lustreless black, giving a uniform appearance to all panels, and it is not affected by oil.

The instruments furnished with this type of switchboard are Westinghouse type K ammeters and voltmeters, utilizing the principle originated by Lord Kelvin. The voltmeter is used either to indicate voltage of the circuit or to determine the extent of a ground. This is accomplished by means of a combined voltmeter and ground detector outfit, consisting essentially of plug switches and a voltage transformer. This device eliminates the extra expense of a special ground detector instrument.

A non-automatic oil switch is recommended for the control of the generator circuit.

Three styles of feeder panels are listed, each having the following equipment:

1. Non-automatic oil switches, with fuses mounted on the panel.
2. Non-automatic oil switches, without fuse protection, fuses to be provided by the customer.
3. Automatic oil switches, eliminating the necessity of fuse protection.

The panel sizes and detail parts are such that they can be packed for mule transportation, making this type of switchboard preferable for installation in places which are not readily accessible for larger panel construction.

The panel sizes and detail parts are such that they can be packed for mule transportation, making this type of switchboard preferable for installa-

tion in places which are not readily accessible for larger panel construction.

A complete wiring diagram is furnished with each switchboard order to aid the customer in installing the equipment.

---

Mr. William Paul Gerhard, consulting engineer and frequent contributor to this magazine, has recently been awarded the honorary degree of Doctor of Engineering by the University of Darmstadt, Germany, this honor being conferred upon him "in consideration of the prominent position which he holds in the United States in matters of hygiene and public health, and also in view of the literary work by which he has promoted and still promotes the theory and practice of sanitary work."

---

**Voluntary Compensation for Injuries**

Notwithstanding the fact that the coroner decided that the accident was unavoidable and that the corporation is blameless, the Otis Elevator Company has distributed nearly $30,000 among the widows and orphans of the victims of the explosion which occurred in its works at Yonkers, N. Y., recently. Four persons were killed and five wounded. Cash in amounts ranging from $3,000 upward has been given to the families, and the widows will also receive each week for one year the wages formerly paid to their husbands. In addition to this, places have been found for members of the stricken families who have desired employment. The injured men have received their full pay, and their doctors' bills have been paid. Such evidence of voluntary aid in a matter in which, by a strict construction of the facts, all liability might have been evaded, is most creditable, and we are most glad to give wide publicity to these facts as an example of whole-souled acceptance of responsibility on broad grounds of humanity by a great corporation.

---

In view of the delays which have occurred in the development of the available coal fields in Alaska, the Alaska Steamship Company has determined to enter upon the transport and use of oil fuel, both for purposes of navigation and for use in the various industrial purposes of the territory. Oil-burning furnaces are being installed on Copper River, on the Northwestern Railroad, the Kennicott copper mines, the Beatson copper mines, the Cliff gold mines, and at Valdez and other points where steam power is used. Tanks have been constructed at Valdez, Seward, Cordova, and elsewhere, and before many months oil will be used as fuel in practically every part of the territory above Ketchikan.

This importation of fuel from external points into a country which is rich in its own coal resources is evidence of the demands which have failed to be met by the official control of the territory, a failure which needs only the application of common sense and strong authority to be converted into a rational solution of a straightforward industrial and commercial problem.

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Our readers will notice that, although this issue of CASSIER'S MAGAZINE is the sixth number of the Fortieth Volume, there is no table of contents for the volume accompanying it. This follows because it has been decided to change the time of division into volumes to accord with the calendar year, and hence Vol. XL. will contain eight numbers instead of six, and will be closed with the issue for December, 1911.

The following volume will run from January to June, and the next from July to December, the calendar year thus being divided into two equal parts of six numbers each.

## Accident Prevention

ONE of the evidences of advancing civilization appears in the increasing extent to which the health and safety of workmen is being considered. In ancient times the reckless disregard of human life led to the sacrifice of thousands in the construction of great architectural and industrial works. Even down to recent periods there was little or no effort made to protect workers other than the general improvement in the knowledge of the strength of materials and the development of skill in their application. Accidents, as they were too often considered, were frequently due either to ignorance or to lack of provision of suitable means for prevention. It was after the disaster had occurred that some attempt was made to avoid its recurrence in the same place or manner.

The great advances which have recently been made in the development and introduction of safety appliances and methods are due both to the general progress in civilization and also to the extending scope of legislation placing the responsibility for injury or death upon the employer. The result of such responsibility has been a far deeper consideration of the side of mechanical appliances which relates to the safety of the employee, a consideration which includes an anticipation of the dangers involved and the use of methods for the prevention of accident.

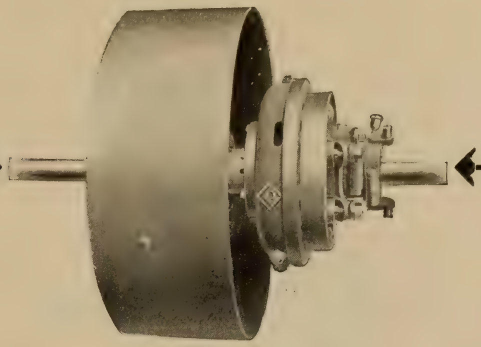
It costs far less to prevent accidents from occurring than it does to remedy the injuries and losses after the event; and there are many consequences of disaster which are irremediable. The wise manufacturer considers the cost of the introduction of safety appliances upon machinery, equipment of buildings in the light of insurance, anticipating possible disasters, and providing defenses against loss.

One of the most important things in connection with prompt action in case of accidents with machinery is the ability to stop the motion of the apparatus immediately. Formerly it was thought sufficient to provide some method of signaling to the engine room, dependence being placed upon the engineer to respond immediately, and, by closing the valve, gradually bring the entire mass of shafting and machinery to rest.

Such methods were both expensive and unsatisfactory. It is practically impossible to bring the entire machinery of a mill to a standstill within a sufficiently brief time to be of use when an operative is caught, and before the momentum of the moving masses can be arrested the harm is done, and possibly lives are sacrificed.

One of the most effective ways of contributing to the prompt control of the machinery of a factory is that of sub-dividing the moving mechanism into sections capable of independent control, both as to starting and stopping. By the arrangement of the machinery into independent groups, each deriving its motion from the main power department and each including effective friction clutches in the transmission system, it is possible to disconnect, almost instantly, the particular line in which any accident or obstruction may occur and bring the parts to a standstill. The comparatively small portion of the machinery involved in any such group brings the momentum within limits which permit prompt arrest, and the control, being in the room where the accident occurs, renders it unnecessary to communicate with the engine room or other distant point and saves the critical moments which may mean the difference between life and death.

The fact that such means for subdividing the transmission of the most elaborate establishment into conveniently handled groups are commercially available and can be installed without requiring any general reconstruction should lead to their general employment in all responsible establishments.



# Safeguard Your MEN and Your MACHINERY

THE problem of safety to your employe—now demanded by the stringent factory laws in most States; the problem of eliminating waste power in **idle** department of your plant; and of keeping the **rest** of your machinery going when some little thing goes wrong, or you must stop to make an installation in one department.

These **all** are solved by the

# DODGE SPLIT FRICTION CLUTCH

With it you can drive your machinery in **independent** groups, without expensive alterations of your present system.

The Dodge Idea reduces accident risk to a minimum.

In case of any accident, when quick action will save a life or limb, the Dodge Friction Clutch, provides instant release in the nick of time.

Every year factory laws are becoming more rigid on this point. Some State laws (Illinois for instance) clearly specify that a friction clutch **must** be used.

If there is no such law in your State, you cannot tell how soon there will be one. Be prepared.

The Dodge Friction Clutch puts you on the safe side at small expense. It is split. That means it can be put up or taken down without disturbing other equipment. It is interchangeably useful for pulley or sheave driving, or for cutoff coupling service, or for attachment to a quill carrying a main driving wheel.

The pulley it carries may be changed at will, or the clutch itself transferred from place to place as wanted, and used either as a pulley driver or a shaft coupler.

For every ordinary use, the Dodge Friction Clutch, which is standardized, may be obtained in stock sizes from Dodge branches and dealers everywhere, on short notice.

Our engineering department will gladly give you correct advice on sub-dividing your power transmission machinery into separate, safe and efficient units. Write for booklet on the Dodge Friction Clutch.

## Dodge Manufacturing Company

**MISHAWAKA, INDIANA**

### Pneumatic Tool Progress

A "PNEUMATIC TOOL," taken individually, is nothing very formidable to look at, and hardly suggests the revolutionary effects following the general introduction of the class of devices which it represents. Only a few years ago lists were being made up of the various tasks which compressed air was undertaking and most successfully accomplishing in practically all lines of human activity, but the list became so large and was growing so rapidly that the enumerators could not keep up with the times and the sport was dropped. It would now be almost as discouraging to try to mention all the employments of the pneumatic tool alone, although it is only a single item of the compressed air kit.

The pneumatic tool is transforming the old-time trades so that the highly developed skill of the workman so requisite in many of them is now a thing of the past, and the workman himself is displaced by the operator. One of the most tedious and constant of the tasks of the machinist of the olden time was the chipping of iron, generally cast iron; this the pneumatic tool now does so much quicker and cheaper, also smoother and better, that the knack of doing it by hand is likely to be forgotten. The rolling up of long, unbroken chips or shavings of soft steel, which the pusher of the pneumatic chisel often can show, is a new art to replace some one of those sentimentally lamented as "lost." Requiring more muscle but less skill, perhaps, was the pulling of the ratchet drill and the tap-wrench, which also the machinist is now pneumatically released from.

The trade of the boiler maker has been entirely transformed by the pneumatic tools which have been put into his hand until there is scarcely a straight hand-work operation surviving. Probably few realize the skill of the expert boiler maker in "driving" the hot rivets by hand and producing the beautiful, smooth, symmetrical, conical heads. Such skill may become a tradition and then a myth. The machined or pneumatic-tooled rivets are better to look at, after all.

The noise of the hammer has not been eliminated, but little else survives, and we hear it constantly as the skyscrapers are going up. The rapidity with which the steel skeletons grow is due to the pneumatic riveters, as well as to the derricks.

Hand hammering throughout the trades, from the driving of nails to the forcing into place of heavy pins and bolts in machine erecting, is becoming a "has been," and the mutilating dents of the hand hammer need no longer be tolerated.

The pneumatic hammer is not more efficient, and ultimately is not more a necessity in the metal trades, than in the other industries where skillful or merely persistent applications of force to cutting tools in detail is required. Stem carving is one of its greatest successes, the most delicate and difficult designs of the sculptor being reproduced in granite or marble with a facility which the ancients could not have dreamed of. The stone-cutting ability is now found just as handy and valuable in cutting asphalt, concrete or macadam where street pavements are to be torn up for any of the modern "improvements."

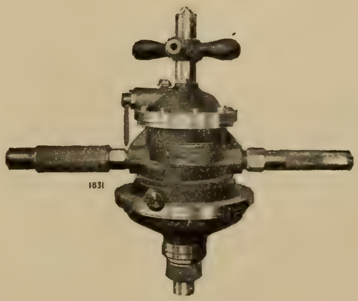
The percussive pneumatic tool follows in principle the hand operation, the chisel or other bit being held tight against the work and the hammer blows being showered upon the head of it. It is curious that the first, and now the established, pneumatically-operated rock drills radically departed from this idea, the cutting bit and the hammer all reciprocating and striking the blow together. These drills, as we know, have been a success the world over; but later the pneumatic tool, embodying the primitive idea, has been replacing them among the miners, and none can say what will be the end of it.

# PNEUMATIC TOOLS

It is the **service** in pneumatic tools—hammers and drills—which gives them value. And **service** is the result only of the widest experience and the best manufacturing methods.

Forty years of building air power machinery have taught us how to put the **maximum service** into an air tool.

This explains the fact that Ingersoll-Rand Pneumatic Tools have the **highest service value.**



COMPRESSORS AIR HOISTS SAND RAMMERS ROCK DRILLS

# INGERSOLL-RAND CO.

**NEW YORK** **LONDON**

**Offices in All the Principal Cities of the World**

### Mass in Machine Tools

A NUMBER of years ago an eminent mechanical engineer called attention to a somewhat novel classification of machine tools, dividing them into two classes—those built on the "fiddle" principle and those designed upon the "anvil" principle. Doubtless each has its appropriate place in the economy of engineering, but it is only in recent years that the full importance of the anvil principle, as applied to machine tools, has been realized. The text-books are filled with methods for computing stresses and for distributing material in such manner as best to resist the consequent strains, but in practice it is found that other considerations besides mere strength have often to be considered. The older ideas concerning the rigidity of certain materials have had to be modified, and it is now generally admitted that all materials must be considered as possessing elasticity, and that something more than mere static forces must be taken into account. This means that much more material is required in bed-plates, frames, bearings and other fundamental parts than is indicated as just sufficient to sustain the working stresses. Vibrations should be checked, so far as possible, at their point of inception, and so absorbed in the mass of metal as to become imperceptible in their influence upon the product. Stiffness often becomes a more important element in the computation of dimensions than the actual forces involved and the ultimate strength of the material employed. Higher cutting speeds, now generally coming into use upon the general introduction of improved tool steels, mean not only higher powering, either of belt or of electric motor, but include a demand for vastly greater stability and capacity to resist vibration, this involving the use of a much greater mass of metal, so distributed as to absorb the variations in the forces and to equalize the stresses.

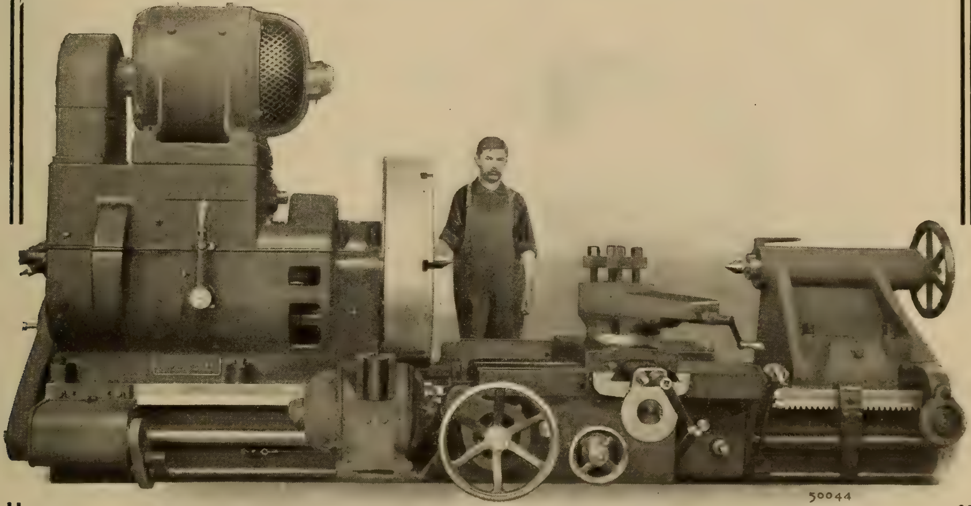
Machines designed in accordance with these fundamental principles are capable of the maximum output which is possible for the capacity of the actual cutting tool, the character of the product being unimpaired. It is interesting to observe the extent to which the introduction of improved tool steels and intensive shop systems has affected machine-tool design. It was at first attempted to meet the new conditions to increase the capacity of tools of existing patterns by providing greater driving power and by minor modifications not included in the original design. Such hybrid machines lacked the essential stability which the increased burden demanded, and the natural course of mechanical evolution has acted to weed out such intermediate types and lead to modern machinery designed in accordance with the "anvil" principle, already mentioned.

The story is told of a certain designer who proportioned a crank-pin according to the exact stresses upon it for the special material employed and then added half an inch to the diameter and an inch and a half to the length, "to make it look right." This does not mean that the rule of thumb is to be preferred to the use of scientific methods of proportioning, but it does mean that experience has often given opportunity for exercise of judgment which may be lacking in the more academic method. The scientific treatment of problems of machine design will give correct results when all the elements in the problem are taken into account, but it is in the very grasp of the fundamental points that the success of the final result depends. The extent to which these fundamental principles have been applied in the design and construction of machine tools of the latest types will be realized by a walk through a modern machine shop; and a comparison of such an equipment with that which would have been considered ample in former years will reveal the extent to which the anvil principle has been applied in present-day practice.

# BUILT FOR SERVICE

# POND HEAVY ENGINE LATHES

**Embody in their design tried principles and long experience covering over 25 years of successful engine lathe building.**



**48″ Pond Geared Head Engine Lathe, Motor Driven**

Simply designed, with the weight most scientifically distributed—an important point for the successful engine lathe. Pond Lathes maintain lasting accuracy and produce smooth work. There is no tendency to vibrate under the heaviest cuts, consequently no chatter marks. No unnecessary parts — no built-up or makeshift devices — the required principles making for success are built *into* Pond Lathes. Attachments for special work are furnished to order. Drive is the most powerful on the market. Headstock is very heavy and massive. Bed is equally heavy to correspond with the headstock. Shafts are of the best hammered steel. Gears are of exceptionally large pitch and wide face. Carriage is rigid. Tailstock is properly braced and holds the work firmly.

Further particulars and specifications are given in the new catalogue, "Heavy Lathes," sent on request. Sizes 26″ and larger.

## NILES-BEMENT-POND CO.

**111 BROADWAY, NEW YORK 25 VICTORIA ST., LONDON, S. W.**

ITALY, Ing., Ercole Vaghi, Milan. JAPAN, F. W. Horne 70-C, Yokohama.
RUSSIA, O. R. San Galli, Nikolajewskaja 17, St. Petersburg.

## The Life of a Metal

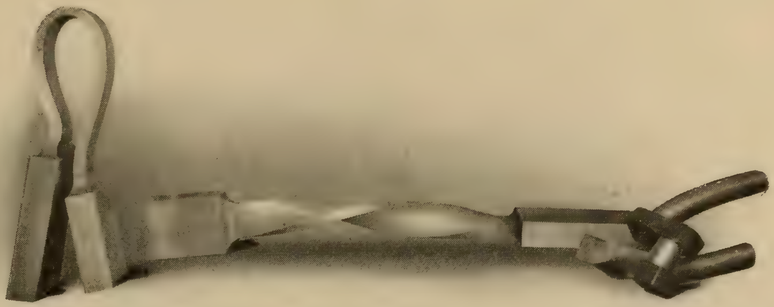
THE term "life," like most important words, has more than one meaning. Even if we divest it of the association with human or animal life, it is always connected with the duration of a period of time in which strength and existence are maintained. It is in this sense that it may appropriately be used in connection with inanimate things. The life of a building, for example, is the period during which it may be expected to stand and to render useful service; the life of a machine is included in the time in which it is actively employed in productive work; the life of a steamship is measured by its term of service upon the sea.

When applied to such a substance as a metal used in the mechanical arts, the word life has a somewhat similar meaning; but it should be modified to a certain extent, because the duration of usefulness of a metal depends upon the manner in which it resists the burdens which are placed upon it. If a metal wire, for example, is bent backward and forward slightly, the fibre stresses thus induced being well below the elastic limit, its endurance will extend over a long period and its resistance not materially reduced. If, however, the extent to which it is bent be increased, the number of alternations which are made before the material breaks will be much fewer; the life of the metal will be shortened. In this respect a metal bears some resemblance to a living being, since it responds to careful treatment and breaks down under excessive burdens. Unlike living beings, however, it has been found possible to modify the strength and resistance of some of the more important metals used in the arts and to give them increased powers of endurance, to enable them to resist greater stresses.

One of the difficulties which the engineer encountered in the use of a material such as steel, for example, was the combination of varied properties demanded in service. The wonderful combinations of iron and carbon coming under the general name of steel might include a metal so hard and to maintain the keenest cutting edge, or cover a material of great ductility and tenacity. Many intermediate grades were possible, each dependent upon the carbon content and the physical structure; but each was peculiar to itself, and each property seemed to be acquired at the expense of some other quality. In the earlier days of engineering work such varied properties caused little difficulty, the demands being limited and the uses fairly well defined.

Under modern conditions, however, the situation is far different. The age of steel, as the present has well been denominated, is also the age of heavy burdens and high speeds, the age of the express train, of the automobile and of the aeroplane. The materials which are required for such purposes must have several commanding properties, instead of a single characteristic, and the same piece is subjected to high tensile and compressive stresses, while, at the same time, receiving shocks of compound and complicated kinds. Under such circumstances it will be realized that the life of the material will be far shorter than formerly, unless, indeed, some elixir of life is found and used to offset the new and severe burdens.

For mankind, as yet, the elixir of life remains undiscovered; but for steel it has been found. The element vanadium, when added in certain predetermined and small proportions, gives to a steel the combined properties of increased tensile strength, higher elastic limit and greater ductility. Strength, toughness, elasticity, united with freedom from crystallization—these are the life-giving properties which vanadium imparts to steel, properties which raise its endurance to meet the burdens which are daily increasing upon it.



Two connecting rods, weight 875 pounds each, and a crank shaft, weight 300 pounds, all made of Vanadium Steel by the Erie Forge Company. These are some of the most remarkable forgings ever made. Tensile strength (annealed, but not heat treated) 134,000 pounds per square inch; elastic limit, 97,000 pounds; elongation in 2", 21%, reduction, 57%.

# Vanadium Steel

Vanadium Steel has the great advantages of workability, tenacity and "life." It forges, rolls, draws, stamps and machines readily. It is at the same time strong, tough, elastic and non-crystallizing—the latter a very vital matter in parts subjected to vibration, torsion or shock. And its wearing qualities are of the very highest type as proved by tests on locomotive tires, crank pins, valves, pistons, etc.

Various types for special purposes make the selection of the proper steel easy and positive. All reputable steel makers sell Vanadium Steel. Our Engineering Department will be glad to confer with you on the subject.

---

**American Vanadium Company**

**335 Frick Building, PITTSBURGH, PA.**

### A Good Front

THERE are some expressions which, although bordering upon slang, cannot well be replaced by any substitute without impairing their force or effectiveness. Among these is the saying that a "good front" is essential to success. Originally this expression was intended to refer to individuals, and conveyed forcibly the influence which a good personal appearance had over individual impressions. Every man who desires to influence others realizes that he can do little if he himself has a careless or neglected appearance, and of two men making similar appeals the one who presents a good front has by far the greater prospect of succeeding. It is doubtless true that the good front must be backed up by more solid qualities, but solid worth has a rather difficult time in making itself appreciated when it is concealed beneath an unlikely exterior.

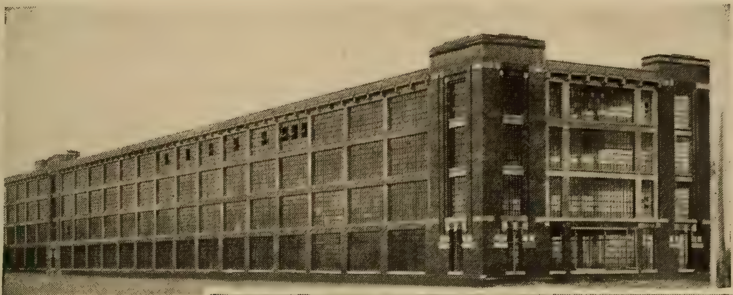
The importance of a good front has been extended from individuals to a wider significance, and in these days of commercial development the character of a manufactured product often depends, in part at least, upon the appearance of the establishment in which it is produced.

The old-time workshop might be permitted to become dirty and shabby, and both without and within it could, and often did, succeed in spite of an unpromising exterior. To-day, however, the value of an effective exterior is more fully appreciated, and the intending purchaser who approaches the bright, well-lighted, efficient-looking establishment enters it already influenced most favourably towards the products manufactured within.

Probably one of the least attractive features of the old-fashioned shop was the windows. Comparatively few in number, poorly constructed, defectively glazed, and frequently allowed to become obscured with grime and dirt, they indicated the general neglect which obtained in other details of administration. When they became too dim to provide proper illumination they were occasionally cleaned; but too often the limited amount of daylight admitted had to be supplemented with artificial sources of light, notwithstanding the fact that ample source of far superior illumination lay just without, requiring only opportunity for admission.

The modern plant, factory or warehouse is a far different kind of affair. The few windows, with weak wooden frames and inconvenient panes, are replaced by steel sash of strength, convenience and ample area, allowing the brilliant light of day to enter, to the marked increase in efficiency and comfort. From without the "good front" makes its truthful revelation of the higher character of the interior, enabling the activities within to be perceived, even before entering, and producing an impression which stamps the entire establishment and its products as of a higher order. Apart from this external impression, the confirmation of the character conveyed by the front follows, and the general effect upon customers and employees alike sustains the effect produced upon approach. A "good front" has become as essential to the business establishment as it has long been to the business man.

The substitution of steel for wood and the evolution of the steel window have revealed some important problems of construction—problems which appear to have been fully solved by the engineers who have attacked them. The steel frame is fireproof and indestructible. Its cost for renewals and repairs is negligible, and its service in advancing illumination and sanitation is now fully appreciated. It has contributed most effectively toward the confirmation of the expression a "good front," as representing a good backing, sustaining the requirements of modern business ethics and providing a correct housing for a successful undertaking.



Exterior and Interior Views of Ford Motor Car Co's. Factory.

Lighted with 85,000 square feet of Detroit Fenestra Solid Steel Windows.

# "A GOOD FRONT"

is one of the first requisites of business success. A handsome exterior of plant, factory or warehouse—many windows revealing cheerful workers sustained by floods of air and sunlight is evidence of the high standard demanded in the business ethics of to-day.

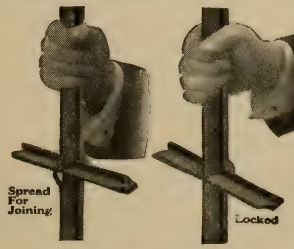
**Detroit-Fenestra**

PATENTED

## SOLID STEEL WINDOWS

are fireproof and indestructible. They leave no argument for the wooden sash of an outlived era. After the initial expense Detroit-Fenestra windows cost nothing. No renewals or repairs—lessen lighting bills and maintenance charges are the result of their installation. The FENESTRA Joint affords marvelous staying power at points of intersection.

**The "Fenestra" Joint**



**Practically No Metal Lost**

Write for Catalog X.

**DETROIT STEEL PRODUCTS COMPANY**

**Dept. 26** **DETROIT, MICH.**

### Washing Dirt Out of Steel

DIRT has been defined as matter out of place, and in the great majority of cases this definition is found to hold good, not only in everyday life, but in the work of the laboratory and the manufactory.

Viewed in this light, very many things which seem clear enough in themselves must be classified as dirt, and as something to be got rid of simply because they are in the wrong place, and not because they are objectionable in themselves. Even such a useful and indispensable element as oxygen, for example, is objectionable in steel, because it occurs as harmful oxides. The element nitrogen, which forms four-fifths of the air we breathe and which is harmless to our lungs, and, in the form of nitrates, is essential to the fertility of the soil, has been demonstrated to be an important cause of brittleness and weakness when it occurs in steel; and, in like manner, there are other substances, either harmless or useful elsewhere, which have, until recently, been the little-known causes of defective rails, broken castings and yielding girders. The same is true of cast iron, the defects in castings being due, in nearly all cases, to the presence of objectionable substances, to matter out of place.

Such being the case, it has long been the aim of manufacturers of iron and steel to cleanse their products, to "launder" them, so to speak, and to wash out the "dirt" which is thus responsible for defects and weaknesses. A certain measure of success has been obtained in this direction by the use of fluxes, such as limestone or fluor-spar; but these are effective in removing only a portion of the impurities, and have no effect upon the oxides or nitrides contained in the molten metal. To launder, or wash the impurities out of iron or steel, and thus enable the full measure of strength and durability to be attained, it is necessary to use something which will unite with the oxides and nitrides, neutralizing their harmful properties and enabling them to be cleansed out into the slag. That something has been found to be titanium. Formerly but little used, but now made available for every foundryman and steel manufacturer in the form of titanium alloy, this element has become the great cleanser for iron and steel, making the operation of washing out the "dirt"—the matter which has no proper place in the great material of construction—simple and certain.

The amount of titanium which is required for this important service is exceedingly small. One-tenth of one per cent. of titanium in rail steel is sufficient to enable a rail to be produced which is far stronger and capable of longer wear than has hitherto been considered possible. Even smaller percentages are found effective in cleansing cast iron, while for special results various proportions are employed.

Let us consider for a moment what this really means. We can send soiled linen to the laundry, and by the use of water, soap and power have it made sweet and clean. The possession of titanium alloy enables us to do the like thing for steel—to cleanse it from the particular impurities which are known to be responsible for the broken rails which have caused so many disastrous wrecks, and to give us a clean, strong and dependable material to which we may entrust our lives and our goods.

This cleansing of steel is accomplished at a trifling cost and without the necessity for the employment of a skilled chemist, the skill being put into the manufacture of the titanium alloy, and thus made available for the working foundryman and steel maker immediately.

There is no reason why defective steel or iron products should longer exist when the means for washing out the dirt—for cleansing them from the harmful elements—are so readily available.

# *The Triumph of*
# *Titanium Alloy*

Titanium Alloy has been on the American market only 4 years. More of it has been sold than of all other alloys combined — excepting silicon and manganese. Manufacturing facilities have been increased more than 1000% to keep pace with orders.

The Titanium rail is an acknowledged success after more than three years' service, because it wears longer, is stronger, and therefore safer than any other rail made at any comparable price. Over 400,000 tons are now in use on more than fifty steam railways, and on the more important traction lines. Ten points more carbon and 0.10% metallic Titanium gives the best rail made at an additional cost not exceeding $2.00 per gross ton of finished rails.

Foundrymen everywhere testify to the really wonderful strengthening effect of Titanium Alloy in iron and steel castings. It reduces the harmful effect of gaseous and solid impurities by combining with them and carrying them off in a fusible slag. It reduces brittleness, makes castings pattern-true, increases resistance to wear and corrosion.

In structural steel, in pipe, in wire—in all forms of steel and iron it betters the product at a comparatively insignificant cost.

***Your library should contain Titanium Booklet No. 31. We will gladly send it free, together with any special information you may request.***

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**THE PRIMOS CHEMICAL CO**
**Primos, Delaware County, Penna**

### Pattern Shop Efficiency

"INCREASE the efficiency of your shops and your profits increase accordingly." This is the modern business slogan and applies to the pattern shop as well as any other.

Increasing the efficiency of a pattern shop, however, is more a matter of equipment than anything else—in other words, to provide tools which will, in the first place, eliminate slow and expensive hand work as much as possible; second, machines which are constructed along lines which eliminate chances of their being out of order when needed; and third, machines which can be easily and quickly changed to do different kinds of work, so that it is kept in use as much as possible.

A machine which meets all of these requirements is a Universal Double Circular Saw, made by J. A. Fay & Egan Company at their big woodworking machinery plant in Cincinnati.

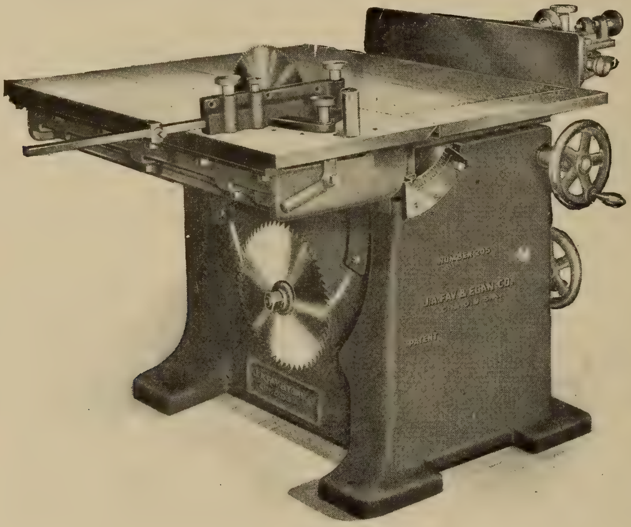
To meet the first requirement this machine will do all kinds of sawing, grooving, dadoeing, etc., from five to ten, or in some cases each twenty times quicker than it can be done by hand.

To meet the second requirement this machine is built on machine-tool principles throughout; every detail is worked out to the smallest degree, making it one of the most accurate woodworking machines ever built.

To meet the third requirement this machine can be used as a rip saw, cut-off saw, slide table or stationary table and miter work. In addition grooving or dado heads may be substituted for the saws.

A feature of this machine which adds greatly to its general efficiency is the solid circular plate which revolves in the frame of the machine and on which are carried the two saw arbors. The importance of this lies (1) in that it does away with the outside support and wall of the column in front of the saws; (2) makes it easy to put on or take off saws without disarranging the table; (3) entirely closes the front of the machine, keeping the mechanism inside free from sawdust; (4) permits the use of two saws up to 16 inch diameter, one on each mandrel at the same time, or if one only is used 20 inches is the limit, and (5) this plate forms a solid bearing for the saw arbors.

The table is made in two sections.



J. A. FAY & EGAN CO.'S NO. 205 DOUBLE CIRCULAR SAW

*Concluded on page* 80.

# FINANCIAL NOTES

**A department of information on industrial and other securities of value to investors and men of affairs.**

OF THE
INDUSTRIAL WORLD

**SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible, the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.**

**CHARLES EASTON, Financial Editor.**

## The Situation.

THE average business man is awaiting with becoming patience the readjustment of commercial interests, and is manifesting a most commendable and persistent confidence in the successful solution of the many difficulties that seemingly beset the industrial world. Men of affairs have overcome their fears of a panic, with the result that no one seriously anticipates any depression in business, but on the contrary are looking forward to a slow, but substantial, improvement in all lines of trade.

Those responsible for the management of large enterprises have been confronted during the past few years with unusual and trying conditions. Such experiences, however, are blessings in disguise, as they teach valuable lessons, one of which is the folly of resorting even temporarily to unsound methods of bolstering up credits. If there is one question more frequently raised than another regarding the character of a business man it is as to his financial responsibility. The fact that a large portion of the world's business is now transacted by means of credits tends to emphasize the importance of individual responsibility. The moral wave which has recently swept over the entire commercial world has greatly quickened the public conscience in general. The old saying that "honesty is the best policy" is now being superseded by a more radical statement, namely, that "honesty is the only policy." The net result of this situation is that people are giving less thought to making a million over night and more thought to the safest and sanest means of extending their business.

There is encouragement to be drawn from the fact that our export business continues to increase. The iron and steel trade reports a prosperous condition, and the industrial activities of the Southern States show greater prosperities than ever before.

It was to be expected that the pessimistic side of the stock market, and speculation in general, would hold undisputed sway during the past month, not only in Wall Street's immediate precincts, but in all the financial and business centers of the country. Conditions have not favoured high prices in stocks, and the lowest level of the year has been reached in the cases of a very long list of railway and industrial securities.

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A. E. Stilger, Vice-President and Cashier
Wm. A. Lobb, Assistant Cashier
Wm. W. Tappan, Assistant Cashier

A multitude of happenings have combined to discourage inflation, and all unnatural tendencies and artificial practices having for their object the creating or maintaining of unjustifiably high prices, either for stocks or the necessities of life.

Public sentiment, political movements, legislation and court decisions all have contributed their share to the cause of present conditions. There should be a recovery from the present dullness and low prices. The restoration, however, of a substantial demand for securities depends largely upon the rapidity with which the various suits under the Sherman law are carried to their conclusions. In the meantime investors will have to suffer for the well-meant efforts of the Department of Justice.

Aside from Wall Street, a better tone prevails in general trade, especially in the West and South, and we look for a gradual improvement from this time until the close of the holiday season.

---

1. *Question*—What are your views of the investment merits of Chesapeake & Ohio?

*Answer*—Chesapeake & Ohio is a standard railroad, so far as physical property is concerned. It has made good progress in the last few years and its gross business is growing steadily. From 1899, through 1908, the dividend rate was only 1 per cent., and large sums were charged back to maintenance. In 1909 the annual rate was made 4 per cent., and in March, 1910, it was increased to the present 5 per cent. In 1910 the balance for dividends was equivalent to 10 per cent. However, in the fiscal year just closing the company's earnings are a trifle more than its dividends. It is therefore conceivable that business might decrease to a point where it would be the policy of wisdom to consider a reduction of dividends.

---

On June 30, 1910, there were 1,699,420 persons in the immediate employ of the railroad companies of the country.

2. *Question*—What is your opinion of the future value of United States Steel common?

*Answer*—The future value of this stock, of course, depends upon general market conditions, and it must be considered that the business of the steel corporation is largely influenced by the periods of prosperity and depression which sweep the country periodically. Steel common is a leader in the industrial group and is extremely sensitive to all changes in price levels. We regard steel common as a speculation, and not as an investment. If you are in a position to assume the risk which it carries there is a good chance of appreciation in value.

---

Among other recent orders received by the Westinghouse Electric and Manufacturing Company was one from the Warren Street Railway Company, of Warren, Pa., for five double equipments of No. 307 motors with type K-36-F control, and another from the Boston Railway Company, Boston, Mass., for fifty additional quadruple equipments of No. 306 motors with type H. L. control.

---

The growing importance of Canada as a grain producer is shown in the fact that the total amount of winter wheat this year is estimated at 17,706,000 bushels, as against 16,610,000 last year. The total wheat crop of the three Western Provinces is expected to reach 200,000,000 bushels. The largest previous crop was 147,000,000 bushels.

---

3. *Question*—Would you advise the purchase of cheap mining stocks dealt in on the curb?

*Answer*—We would not advise you to have anything to do with mining stock selling on the curb at nominal figures.

---

The Railway Steel Spring Company will purchase the plant and property of the Inter-Ocean Steel

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The principal is absolutely safe and the interest certain to be paid as it becomes due.

The bonds are sold at par, bear 6% interest, which is payable quarterly, and mature in ten years.

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They are issued in denominations of $100, $500, and $1,000.

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**The Delaware and Hudson Company**

NOTICE TO MANUFACTURERS

This railroad extends from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines; provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, now being built by the state, connecting the Hudson River with Lake Champlain. An establishment located in this territory receives the benefit of cheap fuel, electric power and low freight rates.
Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

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ALBANY, N. Y. Industrial Agent

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Company, of Chicago, which manufactures car wheels and rims. The Railway Steel Spring Company will issue about $3,500,000 of bonds to pay for the property, following the approval of its stockholders, who will meet soon.

---

4. *Question*—Can listed stocks and bonds be bought on the installment plan?

*Answer*—Several reliable concerns, members of the New York Stock Exchange, are selling listed stocks on the installment plan. You would be perfectly safe in dealing with firms of this character. Bonds are also sold on the installment plan, especially real estate bonds. The Debenture Corporation of New York, 334 Fifth avenue, New York City, are specialists in securities of this character.

---

The American Ship Windlass Company report two notable orders just received for Taylor stokers. The first is for twelve stokers for the New York Edison Company, making a total installation in the Waterside Station of Taylor stokers for 52,650 horse-power of boilers. The second is for five Taylor stokers for the United States Naval Gun Factory, at Washington, D. C. These stokers are to be used under 300 horse-power B. & W. boilers.

---

Bids for borings along the lines of the proposed extensions to subways were opened yesterday by the Public Service Commission. The bidders were Sprague & Henwood, the United Engineering & Contracting Company, the Healy Contraction Company, P. J. Carlin Construction Company. The bids were for borings under Seventh avenue from Fourteenth to Fifty-ninth street, from First to Second avenue, in Sixtieth street, from Fifth to Second avenue, and in Broadway from Fourteenth to Forty-second street. In Brooklyn, East Ninety-eighth street and Lavonia avenue, Nostrand avenue, Stuyvesant avenue and Utica avenue. Under-river crossings, from

Old Slip, Manhattan, under East River to Pineapple street, Brooklyn, and from Whitehall street to Montague street; from the Battery, under the bay, to Atlantic avenue, Brooklyn.

---

5. *Question*—What are the prospects of Baltimore & Ohio continuing its dividends?

*Answer*—Mr. Daniel Williard, president of the Baltimore & Ohio, who recently returned from Europe, said that it was too early to discuss dividends that would not be declared until 1912. Mr. Williard said that he was still of the opinion which he had expressed before, that the Baltimore & Ohio was a conservative, 6 per cent. stock. From the earnings of the first two months of the fiscal year he did not believe that there was any present worry necessary among shareholders about the dividends, as the net earnings for July and August were in excess of the same months of 1910. The company has spent upwards of $20,000,000 in improvements and equipment during the past year, and they still have some extensive improvements under consideration.

---

Coal producers of Tennessee last year received fourteen cents less per ton than in 1907, when the product sold at its highest in four years. The total production in that State in 1910 was 7,121,380 short tons, valued at $7,925,350, an increase of 12 per cent. over the production of 1909. The highest prices attained for Tennessee coal in recent years were recorded in 1907, when the average for the State was $1.25 per short ton. It dropped in 1909 to $1.09. The returns for 1910 show a slight advance. About two-thirds of the mine employees in Tennessee work nine hours a day, and slightly less than one-third work ten hours.

---

6. *Question*—Would you advise depositing money in the postal savings banks?

*Answer*—We do not advise the depositing of money in postal savings

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We will finance a home for you according to your own plan on attractive building site within a few moments' walk of Tuckahoe and Bronxville stations, the highest and most picturesque section of Westchester County, New York, 30 minutes from Grand Central Station, New York, N. Y.

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**New York State Barge Canal.**
By WILLIAM B. LANDRETH
Boston Society of Civil Engineers

**Notes on Pile Protection.**
By T. HOWARD BARNES
Boston Society of Civil Engineers

**Discussion of Paper, "A New Theory for the Design of Reinforced Concrete Reservoirs."**

**Journal of the Association of Engineering Societies**
SEPTEMBER, 1911
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banks, except where the amounts are very small. The 2 per cent. you receive can easily be more than doubled, for you could invest in the same kind of bonds as the Government accepts as security for its deposit. These will pay you from 4½ to 4¾ per cent. They are good investment bonds of the highest class. Those who regard safety as the first consideration should put their money only in securities of this kind. There are, however, many good bonds paying as high as 6 per cent.

---

Plans for a merger of the Public Utilities in Toronto are being considered, to include the Toronto Railway Company, the Toronto Power Company, the Electrical Development Company, the Toronto Electric Light Company, the Metropolitan Railway, the Toronto & Scarboro Railway, the Menlo Electrical Railway, and the Toronto & Suburban Railway.

---

7. *Question*—What do you think of American Woolen preferred?

*Answer*—It is a perfectly safe investment. If tariff meddlers would forget the wool schedule for a while the stock would stand a great deal better. The company is in good hands, and with a revival of prosperity will continue to make a good showing.

---

According to the Inter-State Commerce Commission, the railways of the country carried in the year ending June 30, 1910, a grand total of 971,683,199 passengers, or 80,210,774 more than in the last previous year.

---

President Felton, of the Chicago Great Western Railway, has gotten himself into print by suggesting that a committee of locomotive firemen be sent to England to learn how to use soft coal.

The leading imports of the United States during the last fiscal year were: Copper, $15,500,000; seeds, $13,500,000; tin, $8,000,000; raw cotton, $7,500,000; raw silk, $7,500,000; oil, $9,000,000; chemicals, $6,500,000.

---

According to the Secretary of the American Bankers' Association, the following States have declared in favor of Aldrich's plans for a National Reserve Association. The States are Louisiana, Texas, Kansas, Missouri, Tennessee, South Dakota, Idaho, California, Virginia, Maryland, Minnesota, New York, North Dakota, Georgia, Ohio, West Virginia, Wisconsin, Colorado, Pennsylvania, and the District of Columbia.

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### An Effort to Solve the Difficult Problem of Finding the Right Man for the Right Place

EVERY employer of skilled labor has many times experienced great difficulty in finding just the right kind of a man to suit his particular needs.

On the other hand, many a proficient engineer and skilled mechanic has been compelled to accept an underpaid and uncongenial position merely because he could not get in touch with the man who needed him.

The ordinary employment or engineer agency does not serve the purpose, and engineers and the better class of skilled labor, as well as employers, are wary of such agencies, and with good reason. In many cases the charge to employers is all out of proportion to the service rendered, while in many other cases these agencies seem to be carried on for the sole purpose of obtaining a registration fee from the man seeking employment.

Most engineers have had a similar experience to that of the engineer who is now ranked as a leader in his profession. Shortly after graduating from technical school he registered with a Western engineering agency, paying a $3 registration fee, with the

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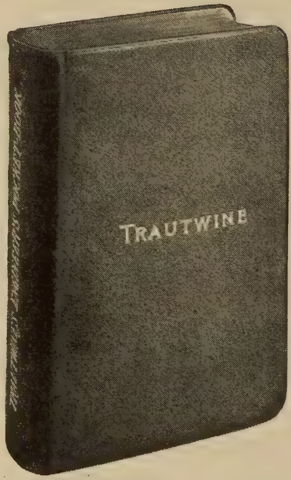

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assurance that in a few weeks he would be placed in some sort of a position.

Months went by without the desired opening forthcoming. He wrote repeatedly, always receiving the same reply, that there was no call for men without practical experience. Finally he gave up in disgust, and you may be sure that his opinion of engineering agencies is not the best.

Appreciating the need of an exchange or bureau that will serve both employer and employee at a fair rate of compensation, and believing that such an exchange would prove a financial success, the Engineering Exchange, at 149 West Thirty-fifth street, was organized. This exchange makes no charge whatever to employers for this service and no charge to employees for registration, charging only the commission allowed and prescribed by the laws of the State of New York, and aims to sift the wheat from the chaff, asking, in fact, whenever possible, three weeks' notice from employers seeking skilled men. In charge of men of undoubted integrity and ability, it will be of great help to both employer and employee, if it keeps up to the standard under which it was organized.

---

The steel work—1,800 tons in weight—of the recently-completed Croisic Realty Building, which stands at the corner of Madison avenue and Twenty-sixth street, New York, and is twenty stories high, had applied to it by the Hay Foundry and Iron Works, both for its shop coat and field coat, Dixon's Silica-Graphite paint. The same paint was used to protect the 5,000 tons of structural steel which extend into the construction of the New Ritz-Carlton Hotel, located at Forty-sixth street and Madison avenue, New York. It was the aim of the builders of both these buildings to use only materials of proven and known merit and which offered permanent and lasting value.

## BOOK NOTES

Hendricks' Commercial Register of the United States for Buyers and Sellers. Twentieth edition. Published by S. E. Hendricks' Company, 74 Lafayette Place, New York. Price, $10.50, delivered.

The first edition of this most complete and valuable work was issued in 1891, since which date it has been issued annually. The twentieth edition has just been issued and is the most extensive work of its kind in existence. It contains complete classified lists of manufacturers of great benefit both to those who want to buy, as well as those who have something to sell, and covers every branch of the architectural, engineering, electrical, mechanical and kindred trades and professions; in fact, it establishes a direct link between the buyer and seller.

An indication of its scope is afforded by the fact that the twentieth edition of the work requires 108 pages for its index. The book consists of 1,600 pages, of which 124 are devoted to new matter, and has over 45,000 classifications, each representing the manufacturers and dealers of some machine, tool, specialty or material required in the architectural, engineering, mechanical, electrical, railroad, mine and kindred industries.

An important feature of this book is the simplicity of its classifications, which are so arranged that it is available for either purchasing or mailing uses, a feature no other publication embodies.

For purchasing purposes its value is not confined to its complete classification alone, but it gives much information following the names of thousands of firms that will prove of great assistance to the buyer, and will also save him the expense of writing to a number of firms for the particular article required.

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The work is complete in every respect and will prove invaluable to both the purchasing and sales departments of any concern, which by its use commands upwards of 350,000 names and addresses completely classified and conveniently arranged.

---

It is announced that the Proceedings of the Congress of Technology, held in Boston, April 10-11, will be published. The single volume of about 500 pages, which will be sold at a moderate price, will contain the seventy odd technical papers relating to many fields of industry which were read at the celebration of the fiftieth anniversary of the granting of the charter of the Massachusetts Institute of Technology.

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Arthur D. Little, Inc., chemists and engineers, Boston, Mass., have been selected to organize and direct an engineering department for the General Motors Company, Detroit, Mich. Mr. D. T. Randall, the resident director, has been connected with the former organization for some years and has had extended experience in engineering problems, as well as in the equipment and direction of several testing laboratories. Mr. Randall was formerly professor of mechanical engineering at the University of Illinois, and later was in charge of the fuel investigations and producer and gas engine tests carried on by the United States Government. He will be assisted in his new position by several men detailed from the Arthur D. Little, Inc., organization.

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At the first annual meeting of the Institute of Operating Engineers, held last month at The Engineering Societies Building, New York, among other papers presented were: "The Operating Engineer's Future," by F. R. Low; "Temperature Changes and Heat Transmission," by Vernon L. Rupp, and "Engine Lubrication," by R. D. Tomlinson, of the Allis Chalmers Company.

# THE LATEST CATALOGUES

**Rings, Shells and Ring Dies**

The Standard Steel Works Company, Philadelphia, Pa., has just issued a new catalogue on Rings, Shells and Ring Dies. This very interesting publication contains illustrations of the various types of this class of material, such as are used in the Chilean, Huntingdon, Griffin or Bradley, Kent, and Bryan Mills, as well as cuts of rolled steel rings, which are used for various other purposes. The catalogue also contains cuts showing gear rims and blanks for built-up gears for heavy electric service, built-up wheels for Bascule bridges, and wheels for mining service. On the last few pages it contains tables of dimensions of peened, screw, welding, and plain pipe flanges, as well as fac simile of dimension blanks used in the ordering of wheels. They are to be congratulated on this very creditable addition to their catalogue list.

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**Core Drills**

The McKiernan-Terry Drill Company, New York, has issued an instructive catalogue devoted to their new core drill, containing much information compiled from extensive operations in the field, which will prove valuable to engineers and contractors interested in core borings.

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**Rotary Converters**

In Bulletin No. 4868, recently issued by the General Electric Company, are illustrated and described rotary converters for railway and lighting, in capacities ranging from 25 to 2,500 kilowatts. The bulletin illustrates also a portable sub-station, in which a converter is installed.

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## Circuit Breakers

The General Electric Company has just issued Bulletins No. 4837 to 3484 inclusive, which form a series illustrating and describing in detail all of the circuit breakers manufactured by that company.

Bulletin No. 4837 contains a general description of the applications of circuit breakers, and contains also notes and diagrams descriptive of standard practice in the use of carbon-break circuit breakers for various requirements. Specifications suggested for the use of engineers, architects and others wishing to secure uniformity in quality of apparatus and illustrations of typical installations of circuit breakers on modern switchboards are given.

Bulletin No. 4838 is devoted to circuit breakers of large capacity for severe service, used in railway, power and lighting installations.

Bulletin No. 4839 describes circuit breakers of intermediate capacities for any service, used in lighting, power and railway installations.

Bulletin No. 4840 is devoted to circuit breakers that are specially adapted to motor-driven tool applications, for use in mills, machine shops, factories, foundries and office buildings, and for general motor work, automobile-charging outfits, storage batteries, rectifier sets, etc.

Bulletin No. 4841 describes circuit breakers for small-capacity motor, lighting and heating circuits.

Bulletin No. 4842 refers to remote control circuit breakers for use in railway, lighting and power installations, especially in those cases where economy of space, ease of operation and distant control are deciding factors.

Bulletin No. 4843 describes magnetic blow-out circuit breakers for railway and power service, and for use especially where the arc must be confined.

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## Southwark-Rateau Steam Turbine

A new illustrated catalogue has been issued by the Southwark Foundry and Machine Company, Philadelphia, Pa., descriptive of Rateau Steam Turbine, manufactured by them. This turbine is of the "impulse" type with one circle of buckets taking the steam from each successive circle of nozzles. As these buckets are perfectly balanced by steam pressure there is no tendency for the steam to leak through the clearance space around them, thus adding greatly to the turbine's efficiency. The Rateau is the simplest of all turbines; it has no auxiliaries to be taken care of, nothing to be kept in exact adjustment and nothing to oil, yet its simplicity is obtained without the sacrifice of any economy.

**Jeffrey Single-Roll Coal Crusher**

The Jeffrey Manufacturing Company, Columbus, Ohio, has issued a bulletin describing their Single-Roll Crusher, which is capable of giving any product required, from the largest to the smallest size, in a single operation by a simple process of adjustment. It will receive coal in any volume direct from a track hopper, grab bucket or mine car without the use of any mechanical device, and can be started up under full load and cannot be flooded or choked down. Other advantages claimed for it are: Ease in adjustment, small power consumption, large range for size and capacity, simplicity in construction and ability to work well under adverse conditions, and is provided with an efficient safety device which protects against shock and accidents.

Those interested in securing the high efficiency which is obtained by using stoker coal in a finely divided shape and who desire to reduce large lumps and run-of-mine coal to stoker size economically will be interested in this catalogue.

The fifth annual meeting of the Institute of the American Peat Society was held at Kalamazoo, Mich., September 21 to 23 last.

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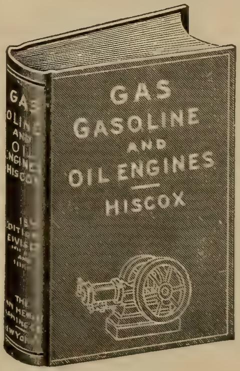

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## Pattern Shop Efficiency

(Concluded from page 64.)

one moving and the other stationary, the latter having an extension for ripping. The whole table can be easily and quickly angled to 45 degrees and is held in place at any angle by a self-locking arrangement. A gauge in full view of the operator registers the angle of the table.

The Ripping Fence can be used on either the right or left side of the table. When used on the left side it forms a support for the material. It can be firmly secured at any angle not in line with the saw, permitting the use of the periphery of the saw to cut semi-circular core boxes of any size. The fence angles to 45 degrees and is provided with micrometer adjustment for close work. The Universal fences angle 60 degrees to right or left. The miter cut-off fence covers a range from 45 degrees back to 60 degrees front. Accurately graduated scales are provided for making all adjustments quickly.

Machines of this class are highly appreciated, not only by the shop owners, as cost reducers, but also by the operators, who are enabled to do better work.

For the benefit of those interested in a tool of this kind the manufacturers have issued a booklet, which may be had upon application to J. A. Fay & Egan Company, 226-246 West Front street, Cincinnati, Ohio.

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The Norton Company, of Worcester, Mass., has issued a neat little booklet, discussing the elements of safety as applied to grinding wheels, and this is especially timely in view of the attention which is now being given to the removal of danger in all lines of industrial operations. Excellent illustrations show very clearly the wrong and right way of mounting grinding wheels, together with various approved types of protection hoods, while views of well-equipped grinding rooms indicate their practical application. Tables of correct speeds are given, and some excellent general suggestions as to the safe operation of grinding wheels.

### A Reliable Independent Water Supply

(Concluded from page 51.)

is belt driven and is equipped with an automatic belt tightener, which keeps the belt always tight. A large air chamber makes the discharge smooth and uniform.

The pump may be arranged for mounting on the wall by substituting brackets instead of the legs.

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The New Britain Machine Company, New Britain, Conn., announces in a handsomely printed circular the fact that it has purchased the plant, patents, and good will of George G. Prentice & Co., Inc., of New Haven, Conn., and that the Multiple Spindle Automatic Turret Machines, hereafter to be known as the New Britain-Prentice tools, will be manufactured exclusively by the New Britain Machine Company. These tools are especially adapted for increasing the production capacity of manufacturing establishments, enabling output to be kept up or increased with far less labor than formerly.

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An extremely attractive pamphlet, entitled "Webster Vacuum Heating System in the Boston City Hospital," has just been published by Warren Webster & Co., Camden, N. J. It describes the installation, in the face of unusual obstacles, of their "Hy-Lo," or Type "D," system in twenty-six buildings of this hospital. The pamphlet will be gladly sent to interested parties if they will write the company at Camden, N. J.

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An attractive publication recently issued by the General Electric Company on the subject of Motor-Generator Sets contains brief descriptions of generator sets of different styles and sizes. These sets are made up of various combinations of alternating and direct-current generators and motors, and range in capacity from 95 kilowatts to over 7,000 kilowatts. The number of the bulletin is 4849.

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# PULLEYS FOR HIGH PERIMETER SPEEDS

IN the transmission of power by belting the amount transmitted depends upon two elements, the pull upon the belt and the velocity at which the belt travels. Theoretically, the greater the belt speed the greater the amount of power transmitted; but, practically, the gain in transmission power from this source is limited by the fact that, above certain speeds, there is danger of bursting of the pulleys, due to the stresses caused by centrifugal force. It is impracticable to increase the strength of the rim of the pulley by adding more metal, because the increased weight of metal causes a corresponding increase in the centrifugal force, and hence the true method to be employed in making pulleys for high rim speeds is to employ material in the rims which shall have the combination of great tensile strength and moderate weight. Those portions of the pulley which do not travel so many feet per minute as the rim are not stressed so severely, so that a pulley of small diameter may be run at a high rotative speed with safety, while one of larger diameter would require more careful construction.

While these facts are well known to engineers, there is lack of reliable information concerning the practicable maximum rim speeds for transmission pulleys, and hence all records of tests in this department of work should be given publicity as guides in an important field of engineering.

Some time ago the Dodge Manufacturing Company, of Mishawaka, filled an order for a wooden rim, iron-centre pulley, 46½ inches in diameter, to be run at a perimeter speed of 9,000 feet per minute. The pulley built to fill this order was tested up to a speed of 10,000 feet per minute, and a companion pulley of the same construction and dimensions was then tested to a speed of 29,200 feet per minute, or more than 5½ miles, without apparent injury. The details of this test were published in this magazine at the time; and we now have additional information of high-speed performance of similar pulleys of larger dimensions.

The Dodge Manufacturing Company accepted an order from the William Slater Mills, Jewett City, Conn., for two pulleys, with wooden rims and iron centres, one of these to be 100 inches in diameter and the other 74 inches in diameter, both 22 inches face, these to be operated at rim speeds of 6,700 feet per minute, to carry a belt 21 inches in width, transmitting 340 horse-power. In order to be assured of safety, the order called for a rim-speed test of 8,000 feet per minute for one hour, the report of this test to be accompanied by a sworn statement.

The pulleys were completed and tested in excess of the requirements, as follows:

The 100-inch pulley was subjected to a continuous test for one hour at an average speed of 375 revolutions per minute, corresponding to a rim speed of 9,817 feet per minute. The 74-inch pulley was tested in like manner for one hour at a speed of 510 revolutions per minute, giving a rim speed of 9,880 feet per minute.

These pulleys were completed in June last and have been in regular service ever since at the desired contract speed, and are reported by the superintendent of the Slater Mills as being altogether satisfactory.

In view of the fact that the pulleys were tested to rim speeds 50 per cent. above the required operating speeds, the latter may well be employed by engineers with confidence, provided the pulleys used conform in design and construction to those from which the data have been obtained.

### A Revision of Standard Screws for Automobiles

THE Society of Automobile Engineers has just announced the details of the S. A. E. screw standard, which supplants the A. L. A. M. screw standard, which was adopted by the Association of Licensed Automobile Manufacturers in April, 1906. The standardizing of nuts and bolts was a work of such magnitude and far-reaching usefulness that it may well constitute an enduring monument. It was work akin to bringing order out of chaos. The standard was an almost immediate mechanical success, the good results being felt not more by manufacturers than by dealers and drivers.

The United States standards for bolts, nuts and screw-threads were originated by the Franklin Institute and adopted by the United States Navy Department in May, 1868. About the beginning of this century manufacturers of fine machinery found from experience that for a large portion of their work the United standards for pitch of threads were too coarse and the dimensions of heads and nuts too large. Where neat appearance and counteraction of the effect of vibration were desiderata, special fine-pitch screws were made. The number and variety of these special threads finally became such that great confusion, inconvenience and unnecessary expense were caused. To obviate this the A. L. A. M. screw standard was employed by a body of experts after exhaustive tests, and, with remarkably little exception, it filled the bill.

The further experience of years proved the necessity of a slight modification of the A. L. A. M. screw standard and of extending it to larger-sized screws. This work the Society of Automobile Engineers undertook, and in conformity with the policy of changing the name of an A. L. A. M. standard, whenever amended by the S. A. E., henceforth the predominant machine screw standard will bear the initials of the society of the designers and producers of American automobiles.

The only changes which have been made by the S. A. E. in the old standard are as to the distance across flats of the heads and nuts of the ¼, 7/16 and ¾-inch screws, the changes being from ⅜ to 7/16, from 11/16 to ⅝, and from 1⅛ to 1 1/16-inch, respectively.

The A. L. A. M. screw standard did not go beyond 1-inch diameter screw. The S. A. E. standard proceeds by ⅛'s to and including 1½-inches diameter screw.

In consideration of the subject, or rather reconsideration, extending over a period of years, the essential points ultimately determining were the dimensions of material commonly carried in stock by manufacturers, their relation to the diameters of screws (and nuts) constantly being made and carried in stock, and the dimensions of standard forged wrenches. Points of mechanical merit being satisfied, the various-sized screws naturally divided themselves into two classes, each to be considered from a different point of view, in one case the proportions being governed by the fact that most of the sizes of screws and nuts would be expected to be carried in stock by the screw makers, in the other case by the openings in forged wrenches of the larger sizes.

The grounds of the Society's action were as follows:

1. That the diameters of the heads conformed to those theretofore established for regular screws.

2. That screws of these proportions can be produced with so little change of the machines making regular goods that it is easy to maintain a stock, or furnish them with little delay if not in stock.

3. That the sizes of material, being regular, are ordinarily kept on hand in large quantities.

4. That the nuts can be made from steel bar or from regular cold-punched blanks under the same ad-

vantageous conditions that apply to the manufacture of screws.

5. That replacements can be made by garage repair men in case of emergency from screws and nuts purchased locally, which can be used as bought or re-threaded S. A. E. standard. In either case the wrench in the regular equipment fits the replacement screws and nuts uniformly with those already on the vehicle.

6. That the diameters of heads and nuts agree with the dimensions of the ordinary cap screws and cold-punched nuts used in the less important places of many of the component parts of various manufacture that enter into the construction of the motor vehicle. This uniformity certainly lessens the number of and facilitates the use of wrenches in making adjustments and repairs.

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### A National Society for the Promotion of Efficiency

UP to the middle of the last century we were an agricultural nation and an exporter of food products. A few factories run by water-power were located along the sea coast. All our laws were framed to meet these conditions. Then came the practical commercialization of the steam engine and the Bessemer process started an era of railroad building, and these two instrumentalities for developing and spreading manufacture all over the country have changed our nation to an industrial one.

In fifty years manufacturing enterprises grew from the small shop with a hundred workmen, all of whom knew their employer, who worked with them and was their friend and adviser, to the gigantic trusts with 250,000 employees, some tyrannous, others benevolent despotisms, all fattening on the people. This change has taken place within the lifetime of those who started it and have been pioneers in it. It has been so rapid that there has been no opportunity to regulate it, much less study and analyze it.

It has been evident, however, that the demand for capable executives has far exceeded the supply, and that this growth has developed, except in notable instances, in the hands of unqualified and unsuitable men. Very recently efforts have been made to formulate and standardize systems of organization and management for the purpose of replacing the haphazard conditions which have existed and which have caused unnecessary waste of materials, useless conflicts between capital and labour, and all constituting gross inefficiency. These efforts are now crystallizing in the formation of a National Society for the Promotion of Efficiency, with headquarters in New York City. Already several meetings have been held, which have been attended by some of the most representative men engaged in those occupations which are related to business, financiers, executives of large enterprises, industrial engineers, public accountants, experts in advertising, selling, purchasing, sanitation, hygiene and social service, as well as lawyers, economists, educators, labour leaders, legislators and government officials. It is proposed to have a permanent home, equipped with a library, meeting rooms and club-house facilities, for the promotion of acquaintance and the interchange of ideas.

Owing to the necessity and importance of the movement, the proposition has been very favourably received, and it is expected that the society will soon become one of the largest and most influential of the national societies. The first meeting for organization will be held in New York City in the very early future.

### Engineering Economics

PROBLEMS in engineering are becoming more and more involved with economic questions. It is not enough that a mechanical device shall do its work well, be ingeniously designed and accurately made. It must justify its existence by earning its cost and increasing the efficiency of the plant of which it forms a part. Many a piece of machinery has failed of its fundamental purpose because the real advantages to be obtained by its use were unduly magnified before it was tried out, even though the apparatus itself performed its functions perfectly. The modern engineer must understand the commercial and economic conditions of the business to the development of which his efforts are directed if he is to be of maximum value to the world.

One of the difficulties in planning improved devices and apparatus for industrial development lies in the imperfect amount of information available as to the actual cost of performing different operations by men or by machinery. Manufacturing concerns are sometimes unwilling and often unable to furnish the facts concerning the operation of devices intended to increase the efficiency of their operation. When a machine fails to realize the advantages expected there is good reason to maintain silence, while if large economies are effected it is often considered best to keep the facts private.

Nevertheless, the engineer must learn, as far as possible, the real efficiencies of existing devices and methods if he is to work intelligently in his efforts to provide improved apparatus, and the collection and dissemination of such information are perfectly legitimate and even necessary parts of his work.

Several sources of information about the relative advantages of different methods of work may be mentioned. Thus, the number of men displaced by a device of evident efficiency was long withheld by the manufacturing concern by whom it was used, but the facts were finally disclosed by the complaints of a labour organization about the number of men who had been replaced by the apparatus. Another method of obtaining information—and a most effective one within the establishment in which the machine or apparatus is used—appears if for any reason the tool is thrown out of use. The number of men required to perform the work during the enforced idleness of the machine may readily be determined, and the data for the calculation of the gain in efficiency thus obtained. By these and similar methods the real value of machinery may be approximated, so far as the actual saving in labour is concerned. Of course, there are other elements in efficiency, such as the improved character of the product, the reduction in time, and in general expense, burden and similar features, which must be estimated.

In one instance a device for lifting and hoisting raw material was found to have displaced twenty-eight men, so that a comparison of the first cost, maintenance and depreciation of the machine with the saving in wages enabled the efficiency of the apparatus to be obtained, so far as operation was concerned, while the gain in time was readily found. In another case an electric locomotive, used for the transport of material upon an industrial railway in a manufacturing establishment, was derailed for two days, during which time it was found that twenty-two men were required each day to perform the work which had been easily and unobtrusively done by the machine.

In the light of such developments the engineer is able to prepare plans and methods for further improvements in efficiency which shall dispense, so far as possible, with the crude and inefficient labour of unaided hands, and replace it with appliances calling for the exercise of intelligence and judgment rather than of muscular effort.

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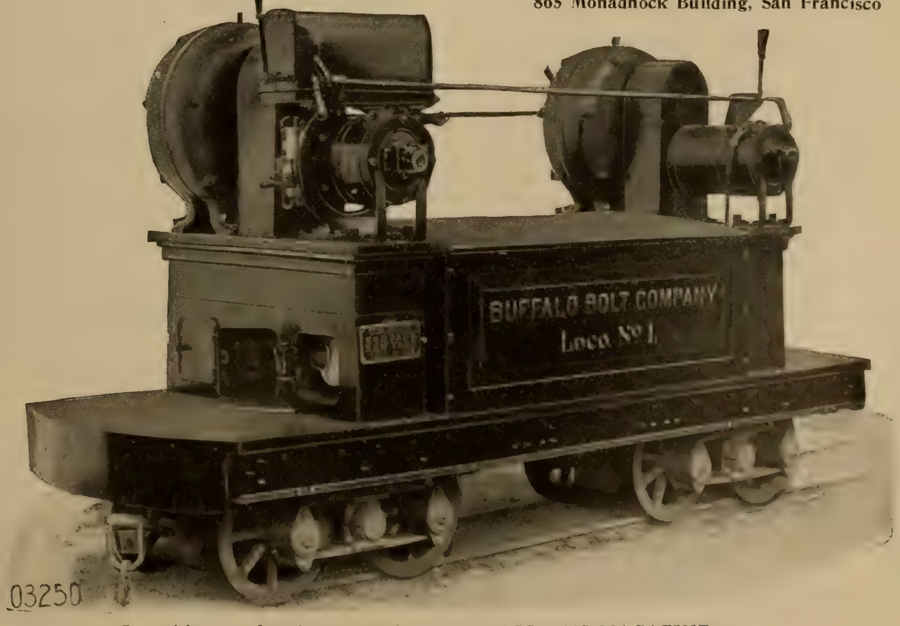


### Keeping in Line

THERE is a well-known expression which applies to many things in the conduct of affairs, both mechanical and intellectual—the importance of "keeping in line," if a desired end is to be attained. This is evidently derived from the mechanical, or rather geometrical, fact that a straight line is the shortest distance between two points, and is thus the most direct path from starting point to goal. Another definition of a straight line, attributed to Gauss, the astronomer, is that a straight line is one which, if revolved with its two ends fixed, does not depart at any point from its original position. To the mechanic this at once suggests the imaginary straight line in the middle of a piece of work revolving between the two centres of a lathe, and it is really at the basis of the production of all truly straight work in any machine tool of the rotative type.

It also applies with especial force to the conditions obtaining in the case of the line shafting by means of which force and motion are transmitted through a workshop or manufacturing establishment. In this case the maintenance of a truly straight line, so that no portion of the line shall attempt to deviate from its true axial relation, is essential to proper efficient action. In the lathe, if any portions of the work do not fall in such proper relation, they soon find themselves in contact with the tool and are cut away. In the case of the line shaft, however, no such corrective action is possible or desired, and if the line is not straight there at once enters disturbing action, involving excessive friction, stress and wear.

When a line shaft is originally erected, it is presumably straight and true, and the hangers and bearings by which it is supported are, or should be, accurately aligned and firmly secured. It is unfortunately true, however, that few such installations are permitted to remain in the correct relations in which they have been placed. Variations in loading upon floors, settlement of piers, unequal belt stresses, burden of pulleys, and especially frequent disconnections and reconnections, combine to affect the truth of the whole and to prevent it from keeping in line.

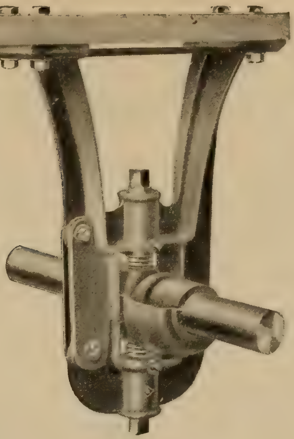
Under such circumstances, it is essential that the properly designed transmission system should include ample opportunity for self-adjustment and for local correction. The fundamental requirement of a satisfactory journal bearing is that it shall be truly in line with the shaft itself. This includes some form of freedom of movement, such as is given by a ball-and-socket support, permitting a small amount of oscillation in any direction to conform to the direction of the axis of the shaft. Such an adjustment is well recognized as an essential to every well-designed hanger; but too often it consists merely of a sort of looseness which permits wabbling in any way, and does not provide really proper support. A true ball-and-socket unites firmness with adaptability, and is self-adjusting, so far as variation in direction is concerned.

There is another set of adjustments, however, which demands individual attention, but which should be capable of being effected easily and accurately. These adjustments provide for the bodily movement of the bearing, both vertically and laterally, to conform to any actual shifting in position of either shaft or hanger. With such adjustments, capable of correcting for any change of position and yet free from independent and unintentional shifting, the problem of keeping the shaft in line becomes simplified to an extent which renders excessive friction losses inexcusable.

The question of lubrication has been met in a number of ways, and the so-called self-lubricating bearings require so little attention that this point may be considered as wholly solved.

**DODGE**

**Ball and Socket Adjustable Hanger**



**DODGE**

**Ball and Socket Adjustable Hanger**

# Most Economical Roadbed for Power

THAT steady, stealthy *loss* that besets so many factories—*excess bearing friction*—can be eliminated easily and at a very moderate cost by the use of ball and socket, self-lubricating hangers and bearings correctly designed and carefully made. It is a surer way than resorting to ball or roller bearings, or individual motors and is far less expensive in both first cost and upkeep.

Dodge bearings reduce friction because there is a true ball and socket connection between the bearing and the fame in hangers and pillow blocks, which permits the bearing to freely align with the shaft. That means equal pressure and reduced friction.

Alignment of shafting is a very important factor in eliminating excess friction and perfect alignment can only be obtained by adjustments which preserve the necessary ball and socket connection. This is accomplished in Dodge hangers by means of a *four-way adjustment.* Vertically by large diameter threaded cast iron plunger screws, machined on the ends to fit the ball on the bearings, and horizontally thru slotted holes in the base of the frame. This is the only proper method of four-way adjustment. The four set screw adjustments used in cheap, inferior hangers destroy the ball and socket feature so essential to the elimination of friction.

In a true ball and socket hanger, with self-lubricating bearings having a perfect and continuous circulation of lubricant, the shaft runs on a film of oil and does not touch the metal lining of the bearing. That is the kind of hanger the Dodge is. For day in and day out, year after year service it is the most nearly "anti-friction," and the most economical shafting bearing on the market to-day.

Dodge hangers and pillow blocks are furnished with ring, chain or capillary self-oiling bearings, all lined with a high grade metal, and *bored* and *reamed.* One filling of oil will last three to six months. They are carried in stock at Dodge branches and by leading machinery and supply dealers in all parts of the country. When buying hangers, pillow blocks, or any shafting bearings, specify Dodge. They will make the best roadbed for *your* power. We will send you Booklet No. 115 telling more about hangers for the asking.

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**Everything for the Mechanical Transmission of Power**

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### The Hoisting Problem

THERE are no industries where the operation of hoisting and lowering of material, of tools and appurtenances, of work in progress or of the finished product, does not frequently and constantly occur, and other means than human muscle have to be provided; but we have been slow enough in getting at it.

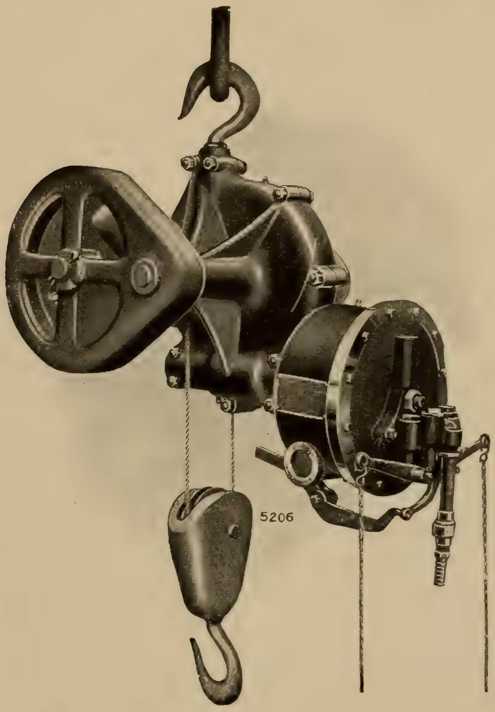
The steam engine is well along into its second century, but we had only the hand-cranked crane and the rope and tackle blocks for all our heavy lifting up to the middle of the last century. Then the differential chain hoist came in. This, though still hand-operated, was a great improvement, in that it would hold the load; but it was slow in operation, both for hoisting and for lowering, and it required about as much power for the latter as for the former operation. The ingenuity of the device did much to give it a start and to continue its vogue so long.

The lifting of weights is one of the simplest operations for which mechanical power can be employed, and where men are still doing it the question is always pertinent as to why such waste of labour is permitted. The actual means by which the power is applied to the specific job must be determined by the conditions. For the simplest lifts we have at once the simplest device which can probably be devised. The direct air hoist is quite common now, but its general employment began only about a score of years ago, and these are still among places where it is conspicuous by its absence. Many industrial concerns even up to the present day have failed to provide for themselves an air supply, and for these, of course, there is an explanation, but not an excuse or justification; but where the air is there should be the air hoist. Quite recently the writer noted the anomaly of a stone yard with pneumatic tools at work but with only hand-operated hoists.

Though the direct air hoist is so simple in its action, responding with ideal promptness to the manipulation of its value for either motion, still its very simplicity and promptness sometimes seem to be in excess. It may hoist too quickly and may not stop the load at the precise point desired, while a careless hand may drop the load too sharply. It also, when the air is shut off, will not hold its load continuously, slight leakage allowing a slow descent—extremely slow, if everything is all right—but still it cannot hold absolutely. The motor hoist has more than all of the desirable properties and none of the objections here suggested. It is entirely responsive to the control of its manipulator. It will hoist at any speed desired; it will stop with precision; it will hold its load absolutely for any length of time; it will lower gently and will not run down to make unnecessary slack to be taken up before the next hoist. It is useful for running along overhead tracks and holding the load suspended from place to place. The desirable features seem to be all there, with nothing to offset them.

The electric air drill made it possible to run an entire mining, tunneling or quarrying plant entirely by electricity and to dispense with the air compressor. The air motor hoist does the reverse of this and makes it just as possible to dispense with the electric current when it is not otherwise imperatively needed and to use only the air. The desirability of using in either case the single style of power transmission is sufficiently apparent. The type of motor which actuates the air-motor hoist can be used, and is used, for driving rotating drills for metal and for other tools in machine shops, boiler shops and elsewhere. Like all other air-operated devices, the motor hoist costs nothing for power or for power maintenance except when it is actually working. When the dynamo stops the electric motor is paralyzed.

# "IMPERIAL" AIR MOTOR HOISTS



Don't pull and tug and pry and shove. **Use an "Imperial" Air Motor Hoist and lift it swiftly, gently and cheaply, swing it where you will, and lower it easily, without a jolt or a jar or a shake.**

Why not keep your men **producing** all the time—not wasting time and energy in doing the work which an "Imperial" Hoist will do better, more quickly and more cheaply?

COMPRESSORS AIR TOOLS SAND RAMMERS

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### Modern Armour Plate

THE development of weapons of attack and defense has for a long time been resolved into a duel between the gun and projectile against the metallic armour with which the sides of battleships are defended.

Sometimes one side is ahead and sometimes the other, and the balance of effectiveness has often oscillated with surprising frequency. Under the older régime of steels, of which the resistance was dependent almost wholly upon their carbon content, it was difficult to see how the limitations of the material could be overcome in the improvement of armour to resist modern projectiles discharged from high-power guns. An armour of high resistance showed evidence of brittleness in the form of cracks, radiating from point of impact, while any attempt at annealing to secure toughness was found to be accompanied with such reduction in resistance as to enable the projectile to pierce the plate. Some attempts at heat treatment were made to produce a plate which should be tough in the mass, while possessing a hardened face; other efforts resulted in the manufacture of a compound armour, formed of layers of hard and soft steel, rolled together. It was not until the development of modern alloy steels, however, involving the use of other constituents besides iron and carbon, came into use that the true path for improvement was opened.

Among the early alloy steels which showed the possibilities of steels with special metallic constituents may be mentioned those containing nickel, and some of the early nickel steels showed properties which rendered them distinctly superior to ordinary carbon steels, so far as the combination of resistance and ductility was concerned. The use of chromium in connection with nickel gave increased hardness without impairing materially the toughness; and, especially for heavy armour plate, the nickel-chromium steels gave good results.

The especial advantage with heavy armour plate lay in the possibility of applying heat treatment in a manner which should provide a hard face and a tough backing in a single mass of material. Thus, in the Krupp armour plate, a system of differential heat treatment permitted the annealing of the back of the plate without reducing the harder temper of the face, owing to the time required for the transmission of the heat from the back to the front of the thick mass. With thinner plates, such as are demanded for deck protection, gun shields, etc., such methods are impracticable, owing to the rapidity with which any temperature effects are transmitted throughout the entire mass.

With the development of vanadium alloy steels, however, the problem of armour-plate manufacture has been immensely simplified, since the combination of resistance and ductility becomes inherent in the entire material, regardless of thickness. Armour plate of vanadium steel has the peculiarity of offering a higher resistance than the harder Krupp plate, owing to the higher ductility. The effect of the impact of the projectile, as shown by tests, both at Indian Head and at the Russian Admiralty Polygon, at Ochta, is to dent the plate, forming more or less of a bulge, but without the production of cracks or shattering effects.

The success which has thus attended the use of vanadium steel for armour plate confirms the theoretical conclusion that extreme hardness or rigidity is not synonymous with maximum resistance, but that it is necessarily accompanied with a proportion of brittleness which is undesirable. The toughness and freedom from brittleness which are characteristic of vanadium steel unite to give a higher degree of resistance to the impact of a projectile than is found with a harder material of less ductility, regardless of thickness of plate.

# A Significant Fact About Vanadium

The status of the Art of Making Steel is invariably judged from the qualities obtained in Armor Plate and in Tool Steel. Metallurgy always reaches its highest point in these two types because every improving process, every strengthening element and every available influence that can be summoned or employed is directed upon the improvement of these steels.

It is significant that Vanadium is the element upon which the present excellence of both Armor Plate and Tool Steels depends. Tool steels with entirely new properties have been developed in the past ten years, as a result of their Vanadium content, and their undreamed of excellency has ceased to astonish us because it is a matter of familiarity. The Vanadium Armor Plate is not so well known, but Brassey's Naval Annual for 1911, the highest and most conservative authority on the subject, makes this comment:

"The Vanadium plate stands by itself in a class apart from all armor plate hitherto made."

Researches on armor plate gave us both nickel steel and nickel chrome steel for general use as a material for all high duty mechanical purposes; similar researches have passed as a step forward and proved the superiority of Vanadium plate; and the logical and historical development is the application of Vanadium Steels to all general purposes where superior strength, tenacity, shock resistance and life are essential.

---

**American Vanadium Company**
**335 Frick Building, PITTSBURGH, PA.**

**Universal Vanadium Co., General Agents**
**NEW YORK LONDON PARIS PITTSBURGH**

# CO-OPERATION OF MACHINES

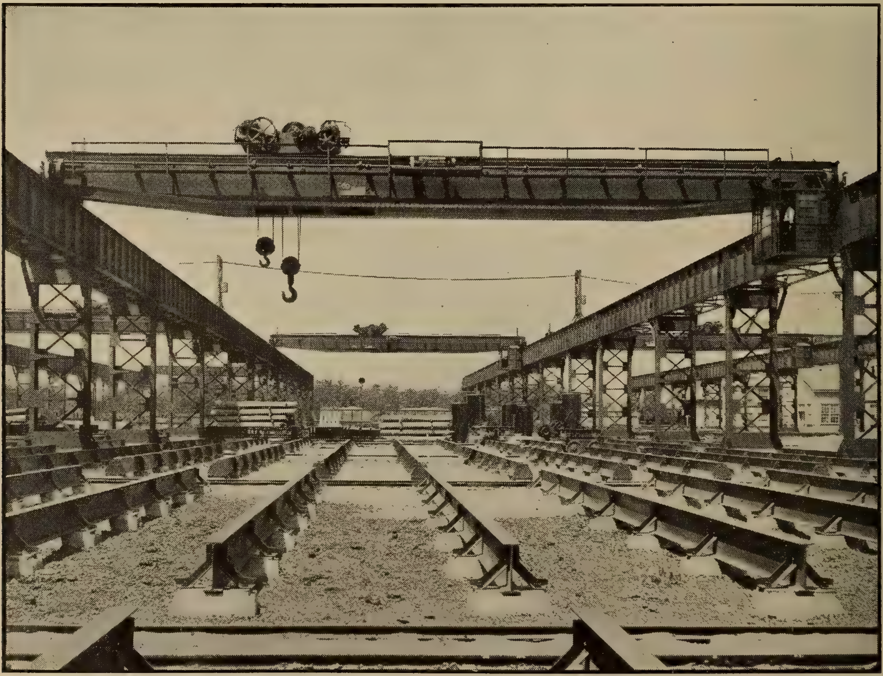
## A GOOD EXAMPLE OF EFFICIENCY IN HANDLING RAW AND FINISHED MATERIALS

THERE is afforded the man who would study up-to-date methods in modern manufacturing an excellent example in the recently completed works of the American Bridge Company, at Gary, Ind.

This assertion is based on the facts that, first, the plant constructed was absolutely new and no account was taken for any remodeling; and second, neither care nor expense was spared to make it the most efficient possible.

From the details of the flooring to the arrangement of skylight volumes might be written on this plant. We shall, however, deal only with that problem, hitherto so many times neglected—the handling of materials throughout the plant; and, to give a clear understanding of this, we will first endeavor to give a description of the arrangement of buildings, yards, etc.

There are two main buildings, each 700 feet long and 300 feet wide. They are parallel and run north and south, the shipping yard being at the former and the receiving yard at the latter end. The transfer bay, which is one of the important parts of the factory, is situated between the two main shops, and connects them at their central points. This bay is about 100 feet wide, and provides not only an ample floor space for storage



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but a convenient communication between the shops.

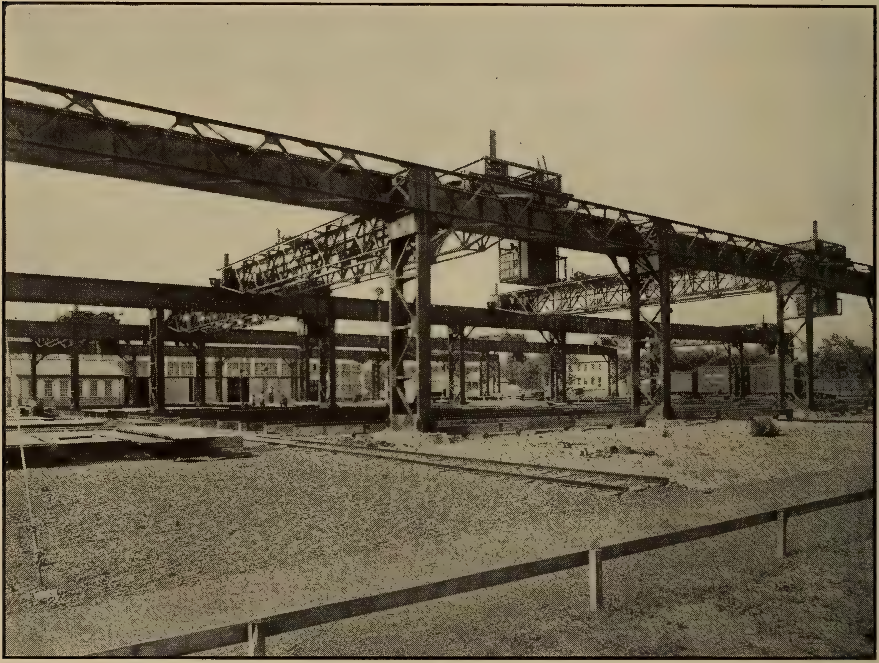
Practically all material in the plant is handled by electric-driven cranes. The receiving yard at the southern end of the property (750 feet long x 270 feet width) is covered by three parallel runways. Each runway has two traveling cranes of 10 tons each. These cranes, of which there is a total of twenty-five, were manufactured by the Cleveland Crane & Engineering Company. Each of these runway cranes is of 90-foot span, and is equipped with two 5-ton hoists. Material is conveyed direct from the railway tracks (which run on both sides and through the center of the property) to large wooden skids.

The shipping yard at the opposite end of the plant is a trifle smaller than the receiving yard. It contains 80-foot runways, on which four 30-ton Cleveland cranes are operated, and also a shorter runway, which is in front of the forge and machine shops, and supports a 30-ton Cleveland crane of 80-foot span. This yard is provided with I-beam skids on concrete.

The rivet shop contains a 10-ton traveling crane of 40-foot span. The crane contains a large receptacle, and when this is filled it moves to the proper bin and unloads its cargo.

Gantry cranes on 12-foot tracks run over the hydraulic riveters in the punch and shearing departments. Cranes working over the 100-ton riveters have 40 tons capacity, while those which handle the 60-ton riveters need to be only of 15-ton capacity. The finishing department contains four reaming gantries.

We have never been acquainted with many power plants which have cranes to move machinery. In Gary, however, a 10-ton Cleveland traveling crane of 40-foot span was in-



PARALLEL RUNWAYS AND ELECTRICAL CRANES FOR CONVEYING MATERIAL DIRECT FROM RAILWAY TRACKS, AMERICAN BRIDGE COMPANY, GARY, IND.

(Concluded on page 78.)

# FINANCIAL NOTES

A department of information on industrial and other securities of value to investors and men of affairs.

OF THE
## INDUSTRIAL WORLD

**SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible, the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.**

**CHARLES EASTON, Financial Editor.**

### The Situation

IT is generally conceded by thoughtful people that the so-called business troubles in this country are more apparent than real. The underlying conditions of business are good, and aside from the political "bugaboo" there is no reason why outward conditions should not immediately improve. The reports from agricultural centers are fair, and our export trade continues exceptionally good. Our financial institutions once more freely accept the bids made by English and European bankers for money at a price much higher than could be commanded at home. This fact, combined with our increased foreign trade, has on more than one occasion in the past served as the foundation for a strong advance in the stock market and for an era of financial and business prosperity. However, before real prosperity will become manifest in the daily round of commerce, the existing order of thought regarding business and the motives of the men charged with its management must undergo a change. There must be an unselfish desire on the part of those representing the Government and those representing corporations to work out their differences in such manner as to avoid trade disturbances and minimize possible loss to innocent shareholders. This can only be done by each of them meeting the various issues fairly and squarely, when and as they present themselves, without any attempt to secure political or financial advancement at the expense of justice. Capital will remain timid just so long as public officials continue to apply to our successful business men the unjust law, once popular on the Western frontier, of hanging a man first and trying him afterward. The restoration of confidence is the one essential thing, and much could be done in this direction by men who are regarded as party leaders, if they would apply constructive, rather than destructive, ideas to the business situation.

During the past month an encouraging change has taken place on the part of the investing public. Banking houses report that the anxiety shown in the early fall by investors as to the stability of the stocks they own has given way to a desire to learn about the merits of special issues with an apparent inclination to invest.

A few wise prognosticators seem to think that the pendulum of Wall Street is slowly beginning to swing in the right direction.

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Wm. A. Lobb, Assistant Cashier
Wm. W. Tappan, Assistant Cashier

*Question*—What would you advise concerning the bonds and stocks of the Allis-Chalmers Company?

*Answer*—The Allis-Chalmers Company recently issued a statement, in which it stated that for some time past the new business was far from satisfactory, and the products of the company not being a necessity the volume of trade is suffering. The company's collections are slow, since a part of its business is done on long-time credit, and some of it with concerns which are most susceptible to periods of depression. This information partially explains the behaviour of the company's securities in the open market. The bonds and stocks of the company are unquestionably speculative, and we could not advise them as an investment.

---

A preliminary statement of the general results of the Thirteenth United States Census of Manufacturers of the State of New York shows an increase in all of the items covered. There were 44,935 manufacturing establishments in 1909, and 37,194 in 1904, an increase of 7,741, or 21 per cent. The capital invested, as reported in 1909, was $2,779,497,000, a gain of $748,037,000, or 37 per cent. over 1904. The average capital per establishment was approximately $62,000 in 1909, and $55,000 in 1904. The value of products was $3,369,490,000 in 1909, an increase of 35 per cent. over 1904. The average number of wage-earners employed showed an increase of 17 per cent.

---

The United States Steel Corporation is to-day confronted with many problems threatening its progress and development; the following are the more important: Breaking up of the "harmony of interests"; plan for maintaining reasonable prices for steel products; movement to segregate the railroads of the corporation and force iron ore freight rates to a much lower level; the Government's threatened suit to dissect the corporation; the Stanley committee activities.

and the proposed reduction in steel duties. It is believed the corporation will prove equal to the occasion, and will emerge from the struggle stronger than at any time since its organization. The steel market is now an open one, with each company scrambling for business on a basis of its own prices. This means widely fluctuating markets. If the Government should declare the steel corporation a monopoly, in so far as its holdings of ore land are concerned, there will be considerable uncertainty about the continuance of the corporation's lease of the Great Northern ore lands. There are many rumors as to the character of the report of the Commissioner of Corporations on steel. Many believe it will be of a drastic character.

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*Question*—What do you think of Missouri Pacific?

*Answer*—We regard Missouri Pacific favorably for a long-pull speculation.

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In order to take care of its constantly extending business the Brown Hoisting Machinery Company, of Cleveland, have recently opened a Chicago office in the Commercial Bank building, with M. A. M. Merryweather as its manager.

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At a conference of Southern cotton growers in Montgomery, Ala., it was resolved that cotton is worth 15 cents a pound, and growers were urged to hold for this price. It was stated that the native crop in this country will not exceed 12,500,000 bales, and that a French-English syndicate stands ready to finance the crop.

---

Fifty New York banks have a total capital of $135,150,000; a surplus of $196,199,000; average loans, $1,354,988,000; specie average, $290,361,000; legal average $78,197,000; net deposits, $1,383,624,000; reserve, 26.6 per cent.

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The Delaware and Hudson Company

NOTICE TO MANUFACTURERS

This railroad extends from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines; provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, now being built by the state, connecting the Hudson River with Lake Champlain. An establishment located in this territory receives the benefit of cheap fuel, electric power and low freight rates.

Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

IRA H. SHOEMAKER
ALBANY, N. Y. Industrial Agent

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*Question*—Is it possible to secure 6 per cent. on first mortgages on New York real estate?

*Answer*—There are many small mortgages on well-selected real estate that pay 6 per cent. Mortgages running into larger amounts on a modern office building or apartment house seldom pay more than 5 per cent. The Debenture Corporation of New York, No. 334 Firth avenue, New York City, are specialists in real estate securities, and its recommendations can be depended upon.

---

It is interesting and encouraging to know that Senor Madero, who recently succeeded to the Presidency of Mexico, is a gentleman of high attainments, and is splendidly equipped by years of experience in commercial lines to successfully conduct the business policy of his government. With the view of establishing closer commercial relations with the United States the Mexican Government recently appointed Senor Heriberto Barron a special business representative, with authority to establish in New York City a bureau of Mexican information and permanent exhibit of Mexican products.

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*Question*—What do you think of bank stocks as an investment?

*Answer*—First-class bank stocks are very highly regarded, especially those of well-established and prosperous banks in our great cities. They usually yield a reasonable rate of interest and enjoy occasional extra dividends of a generous nature. As an example one bank in New York City recently declared an extra dividend of 40 per cent.

---

According to the Bureau of Corporations there have been added to the United States Steel Corporation since its organization $500,000,000, and its tangible property now represents the huge sum of $1,402,000,000. The net earnings of the corporation since it began business have aggregated $1,202,214,515.

On September 25 new low records of the year had been made by seventy-two stocks, the latest addition having been largely produced by the industrials.

---

The copper situation, according to Boston reports, is explained in the following words: "With the price shading off and the demand abroad apparently satisfied, and with market conditions at home disturbed, copper gossip is at a low ebb. The depreciation in the price of Calumet and Hecla stock is, of course, a predominating feature."

---

While there is nothing like definite information regarding the intention of Lehigh Valley to segregate its coal properties from its railroad, nevertheless the gossips of Wall Street have been paying considerable attention to the rumor, because of the investment buying of Lehigh Valley. The strength shown by the Lehigh Valley might explain the mysterious heaviness recently manifested by Reading. While the selling of Reading went on there was a continued accumulation of Lehigh Valley, and the latter operation was undoubtedly helped by the former.

---

The General Electric Company, of Schenectady, N. Y., report the receipt of many large orders, among them the following:

Metropolitan West Side Electric Railway Company, Chicago, Ill.—Two 2,000-kilowatt, 600-volt rotaries; six 700-kilowatt. 9,000-430 transformers; two 20,000 cubic-foot blower sets; switchboard.

Fairmont & Clarksburg Traction Company, Fairmont, W. Va. For Clarksburg, W. Va.—Three 300-kilowatt, 1,200-600-volt CW rotary converters; nine 110 KVA. transformers; switchboard.

The City & County Contract Company, New York City. For New York, Westchester & Boston Railway Company.—One gasolene-electric equipment for construction car and control equipment.

Des Moines City Railway Company, Des Moines, Ia.—Switchboard.

**How to Finance a Suburban Home**

We will finance a home for you according to your own plan on attractive building site within a few moments' walk of Tuckahoe and Bronxville stations, the highest and most picturesque section of Westchester County, New York, 30 minutes from Grand Central Station, New York, N. Y.

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**An organization of water works managers and engineers, for the improvement of public water supplies and water supply business.**

**The Association holds annual conventions, and publishes the Proceedings thereof.**

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Address
**J. M. DIVEN, Secretary**
**14 George Street**
**CHARLESTON, S. C.**

**The Engineering Problems of Land Reclamation, with discussion.**
By ARTHUR M. SHAW
Louisiana Engineering Society.

**Water Resources of the State of New York.**
By WALTER McCULLOH
Boston Society of Civil Engineers.

**Discussion of Paper, "The Emscher Sewerage District and the Imhoff Tank."**

**Discussion of Paper, "The Design of Eccentrically Loaded Concrete Members Reinforced on One Face Only."**

**Journal of the Association of Engineering Societies**
OCTOBER, 1911
30 cents per copy $3.00 per annum
Fred. Brooks, Secretary
31 Milk St., Boston, Mass.

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Lewiston, Augusta & Waterville Street Railway Company, Lewiston, Me.—One 300-kilowatt, two-unit motor generator set and switchboard.

Waldameer Construction Company, Erie, Pa. For Erie & Suburban Railway Company.—One GE-205 4-motor car equipment with K-34 controller.

Pacific Electric Railway Company, Los Angeles, Cal.—One motor generator set; one 17-kilowatt, 500-125-volt exciter; three WC-50-450-15,000/13,500-2,250-volt core type transformers.

Delaware & Hudson Company, Albany, N. Y.—One gas-electric motor car.

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The Corrugated Bar Company have announced the removal of their headquarters from St. Louis, Mo., to Buffalo, N. Y., which occurred on the 14th of October. They occupy the third and fourth floors of the Mutual Life building in Buffalo.

The change in headquarters was decided upon, as their stock warehouse and fabricating plants are located near Buffalo. The move will enable them to give their customers better and more prompt service in the handling of orders.

District offices will be maintained in the National Bank of Commerce building, at St. Louis, as well as in New York and Chicago.

---

The main offices of A. Eugene Michel and Staff, Advertising Engineers, have been moved into the Park Row building, 21 Park Row, New York, where larger space has been secured, as necessitated by constantly increasing business. Temporarily the photo re-touching and illustrating department will remain in the Hudson Terminal Buildings, but all business will be managed from the new offices.

---

Registration at the University of Illinois began on September 18, and the work of the new year formally started on the 21st. The total enrolment of students on October 1 in the various departments at Champaign-Urbana was 3,620. Of this number, the College of Engineering is credited with 1,206, distributed as follows :

| | |
|---|---|
| Architecture and Architectural Engineering | 306 |
| Civil Engineering | 251 |
| Electrical Engineering | 290 |
| Mechanical Engineering | 275 |
| Mining Engineering | 21 |
| Municipal and Sanitary Engineering | 27 |
| Railway Engineering | 36 |
| Total | 1,206 |

### Guaranteeing Skilled Men a New Departure

The Engineering Exchange, at 149 West Thirty-fifth street, New York City, has been recently reorganized under the name of The Employers' Guarantee Company, and, as the name implies, this company guarantees men hired through its mediumship to be satisfactory in every respect, backing up the guarantee by contracting to refund to the dissatisfied employer a sum equal to the employee's trial salary.

The Employers' Guarantee Company looks up each man's record in detail, and if there is a shadow of doubt as to his reliability or fitness he is not regarded as a first-class man.

This plan should be hailed with satisfaction by all employers of skilled labour, removing, as it does, all responsibility from their shoulders and eliminating the necessity of investigating the references and trying out half a dozen men in order to find one who just fits the niche designed for him. In fact, this plan should be as valuable to the employers in the insuring against the danger of loss by unsatisfactory help as fire insurance is against the danger by fire.

The Employers' Guarantee Company will continue to furnish first-class engineers and machinists, as did its parent, the Engineering Exchange, and will also furnish all kinds of first-class commercial and professional help; but, because of the unexpected increase of business, asks that the firm or individual who needs men will give notification as far in advance as possible.

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You make the final selection
We guarantee your choice

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# BOOK NOTES

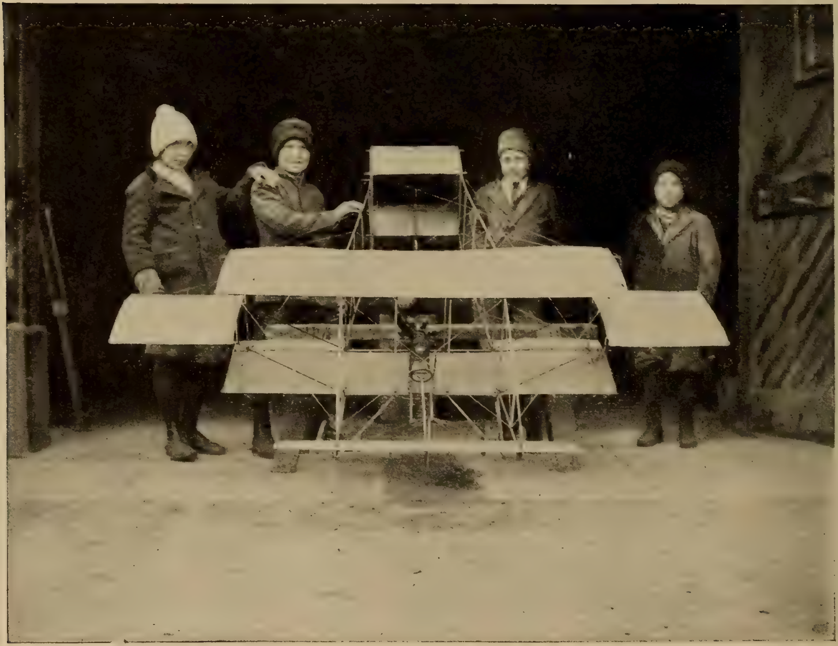
### Model Aeroplanes—The New Scientific Toy

The Second Boys' Book of Model Aeroplanes. By Francis A. Collins. 300 pages. 100 illustrations. The Century Company, New York. $1.20 net. Postpaid, $1.31.

THE remarkable development of model aeroplanes is beginning to attract serious scientific attention. The universal interest in the science of aviation has naturally been shared by boys, who at once set about building flying machines of their own. At first the models of the large man-carrying craft were rather futile little toys, which would fly for but a few feet. But the boys, thousands of them, have kept at their task until they developed a miniature craft which would actually fly. The record distance flight to-day is 2,600 feet, while flights of one-quarter of a mile are common. Could a better illustration be needed of the inventive genius and mechanical skill of the average American boy?

The designing and building of model aeroplanes is not only a fascinating work, but an excellent scientific training as well. Successful machines have been built by boys of ten years of age. The young aviator in this way soon gains a knowledge of the principles of aviation which he could scarcely learn from the text books. The value of the work has been quickly recognized by the manual training schools, a number of which have encouraged the formation of model aeroplane clubs. The athletic departments of the Y. M. C. A. associations have formed scores of such clubs throughout the country.

Model aeroplaning is the most democratic of pastimes. The materials used for making models cost practically nothing, and are within the reach of all. It engages boys both in the workshop and out of doors, affording plenty of fresh air



and exercise. The marvelous little air ships will fly faster than a boy can run

An excellent book on the subject is afforded by the "Boys' Book of Model Aeroplanes," by Francis Arnold Collins (The Century Company). The book makes very interesting reading for the grown-ups as well as for the boys. Its treatment of the science of aviation is vivid and explicit. It tells just how to make and fly these marvelous little air crafts so simply and helpfully that anyone may understand. The volume is illustrated with more than one hundred photographs and drawings of successful models.

---

### Notes on Heating and Ventilation

Notes on Heating and Ventilation. By Prof. John R. Allen, Third edition. Published by *Domestic Engineering*, 443 South Dearborn street, Chicago, Ill. Cloth bound, $2.50.

A complete and scientific study of heating and ventilation, both in practice and theory. The subject is covered with admirable clearness and judgment, so that this work may be regarded as a full and absolutely reliable guide in solving all heating problems.

The scope of the work includes all the accepted heating systems—direct and indirect steam, hot water and hot air and vacuum, together with general instructions regarding ventilation and piping.

---

### Electric Traction and Transmission Engineering

BY DR. SAMUEL SHELDON

Among the new books announced by the D. Van Nostrand Company, of New York, attention may be directed to the treatise on Electric Traction and Transmission Engineering, by Dr. Samuel Sheldon and Mr. Erich Hausmann. It is a thoroughly modern and comprehensive treatment of a subject of immense commercial importance, and presents a practical view of a complete electric railway installation, from the cars to the power station. The book contains many tables, diagrams and illustrations, and costs $2.50.

The Second
BOYS' BOOK
OF MODEL
AEROPLANES
By Francis Arnold Collins

The book of books for every lad, and every grown-up too, who has been caught in the fascination of model aeroplane experimentation, covering up to date the science and sport of model aeroplane building and flying, both in this country and abroad.

There are detailed instructions for building fifteen of the newest models, with a special chapter devoted to parlor aviation, full instructions for building small paper gliders, and rules for conducting model aeroplane contests.

*The illustrations are from interesting photographs and helpful working drawings of over one hundred new models.*

*The price, $1.20 net, postage 11 cents*

The Author's Earlier Book

THE BOYS' BOOK
OF MODEL
AEROPLANES

It tells just how to build a "glider," a motor, monoplane and biplane models, and how to meet and remedy common faults—all so simply and clearly that any lad can get results. The story of the history and development of aviation is told so accurately and vividly that it cannot fail to interest and inform young and old.

*Many Helpful Illustrations*

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Union Square NEW YORK

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**The Publisher FLYING NEWS, P.O. Box 1174, Atlanta, Ga.**

### An Appreciation of American Manufacture

The old saying that the proof of the pudding is in the eating thereof is well illustrated in the letter recently written by an English engineer, Mr. Ernest Jackson, of 188 Cornwall Road, South Tottenham, London, to the Dodge Manufacturing Company, of Mishawaka, Ind., and gives another instance of high esteem in which their products are regarded by engineers throughout the world. Mr. Jackson writes as follows concerning his experience:

"Exactly ten years ago I completed the equipment of a large factory in North London. The whole of the main-line shafting and counter shafting in this factory was fitted with Dodge ball and socket adjustable hangers, with bearings of the capillary self-oiling type.

"I felt great confidence in these bearings at that time, and the result after ten years' service has only been to increase it. I find that not a single bearing has had to be replaced, neither has a bearing at any time run hot during the whole of the ten years' working.

"The other day I examined a bearing which has been in use for the whole period and which still shows no appreciable signs of wear.

"I have ordered the Dodge line from Isaac Braithwaite & Son, of London, as occasion arose, during the last ten years. I want to say that it is the most economical in use, and exceedingly satisfactory."

Both the Dodge Manufacturing Company and the American engineering profession should be proud of such a flattering testimonial to American design and construction.

---

The Westinghouse Electric & Manufacturing Company has just issued the first edition of a small monthly publication entitled "Small Motors," which is devoted to forming a co-operative bond between the manufacturer and the dealer in small electric motors for general household, store and office work.

**Aircraft**

**An Encyclopedia of Aeronautical Development Published in Monthly Installments**

**Read by everybody interested in the Subject**

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**From June to November**

**the issues containing this splendid story**

**A Man from the North**

**By Arnold Bennett**

*Address:*

The Book News Monthly
Philadelphia
Penna.

The publication is devoted to practical applications of small motors, showing views of motors in actual service, such as operating ice-cream freezers, small lathes, washing machines, grinding wheels and numerous other household devices.

An interesting application of the small motor for the household is its use as an auxiliary to the furnace, assisting the heating and ventilation of same. By means of a blower attachment the motor may be used to increase the draft, to increase the distribution of heated air by drawing it from the pipes and forcing it into the room, ventilating a steam-heated room, and in numerous other ways assist in the heating and ventilation of the home.

Advice as to installation, operation and care of the motors is given in short, practical talks.

"Small Motors" is distributed to central stations and dealers the first of every month.

---

The three articles by Mr. J. F. Springer, which appeared in this magazine in the months of July, August and September last, on the "Water Supply of a Great City," and which attracted so much notice, are to be issued as a separate pamphlet, handsomely printed, by the A. S. Cameron Steam Pump Company.

These articles contain much of interest, and the pamphlet will prove of service to those who desire to keep a record of the great engineering work that has been done in the construction of the Catskill Aqueduct.

A copy may be obtained by addressing the A. S. Cameron Steam Pump Company, foot of Twenty-third street, New York, and mentioning CASSIER'S MAGAZINE.

---

The Alloy Steel Casting Company, of Wheeling, W. Va., announces the completion of its works and invites inquiries for high-grade ingots and castings of vanadium steel and other composition steel.

Special attention will be given to the making of small special alloy castings and mixtures for remelting.

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Special rates for definite amount of space contracted for to be used as desired during one year, and not more than four inches in any one issue.

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**WANTED—By a large corporation, near New York, a Technical Graduate experienced in elevator, conveyor and structural steel design, salary about $35 per week. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., 149 West 35th Street, New York, N. Y.**

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Expert Translator of French, Italian, Spanish desires temporary or permanent work. Resides in New York. "Translator," care Cassier's Magazine.

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WANTED—By architect in New York, draughting and designing for evenings. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., 149 West 35th Street, New York, N. Y.

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WANTED—By large manufacturer, near New York, young man experienced in machine shop, must be good draughtsman and familiar with printing machinery. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., 149 West 35th Street, New York, N. Y.

## EMPLOYERS' LIST

(Continued)

---

**TRAVELING SALESMAN WANTED—By large Machinery manufacturers; must have had experience as agricultural machinery salesman or as salesman to hardware dealers. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., 149 West 35th Street, New York, N. Y.**

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ITALIAN LESSONS—By experienced Tuscan teacher of Italian. Highest New York references. Terms reasonable. "Tuscan," care Cassier's Magazine.

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A young man with four years' business experience wishes a position as salesman or New York City representative for some reliable concern, who will appreciate a good, hard worker, and will offer advancement. Address 101, care Cassier's Magazine.

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**WANTED—By Mechanical Engineer, in New York, draughting for spare time. Specialty: design of tools for interchangeable machinery. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., 149 West 35th Street, New York, N. Y.**

---

**Engineer with American business experience, residing in Italy and engaged in the introduction of American articles there, desires to hear from a few other firms who would like to have their goods introduced in Italy. At present there is a large demand in Italy for many articles of American invention and manufacture. "Italy," care Cassier's Magazine.**

---

Position desired as foreign correspondent by highly educated young man, university training, speaks fluently French, Italian, English, also Spanish. Temporarily employed, but to secure permanent position in or near New York with chance for advancement, would accept small salary to start. Best references. "Correspondent," care Cassier's Magazine.

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**BEVEL GEAR TABLES**

Shows every dimension and every angle of any bevel gear you're likely to need in 10 years. Saves time and mistakes in laying them out in drawing room, or setting the gear cutter. Plainly told.

**$1.00**

**CHANGE GEAR DEVICES**

A history of the Screw Cutting Lathe from way back in the beginning. Written by a designer who has had to have information on Change Gear designs and here set forth for the benefit of those who don't know.

**$1.00**

Any of these books sent
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**The Norman W. Henley Pub. Co.**
128 NASSAU STREET, NEW YORK

## Co-operation of Machines

(Concluded from page 66.)

stalled for this very purpose. In the forge shop a 5-ton 60-foot span traveling crane has displaced the old-style hand hoists. The main bay of the machine shop contains a Cleveland 25-ton crane with 60-foot span. Working over the machine tools are 2-ton revolving traveling jib cranes, made and designed by the American Bridge Company themselves. These small cranes and the large ones all work in co-operation.

Speaking of co-operation, the term is usually applied to the human race in such cases as the fire department, politics, police department, etc. But for co-operation of machines let us commend the ingenious brain who devised the system of the assembling hoists. The hoists operate on 20-foot runways, which are parallel, and extend not only through the shops but also the transfer bay. The hoist tracks are so closely and accurately placed that loads may reach any part of the shop or bay whatsoever, which means that a hoist may be transferred from one runway to another. The northern end of each building is additionally equipped with two 40-ton 40-foot span Cleveland traveling cranes, and the side bays are taken care of by 10-ton cranes of similar type and span.

Throughout the entire plant there is an industrial railway system of 3-foot gage. In the important departments there are four tracks, and all grades have been carefully provided for.

In closing, there is no need to dwell on the great saving made possible by this system of crane-handling material. The mere fact that one of the greatest corporations in the world to-day indorses such a system immediately establishes its efficiency and economy.

# THE LATEST CATALOGUES

## Compressors

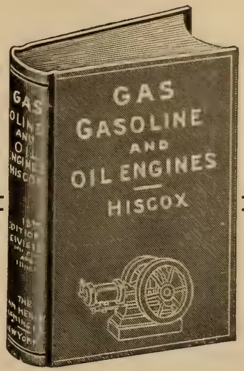
"Compressors" — Ingersoll - Rand Company, 11 Broadway, New York City. Form 3210, bulletin of twelve pages, descriptive of Class NE-1 power-driven, single-stage, straight-line air compressors. This compressor consists of an air cylinder supported by a main (frame with a piston operated by means of a center) crankshaft with a belt-wheel on one side and a fly-wheel on the other. Shaft and wheels can be reversed in the bearings if the belt-wheel is preferred on the other side. Air inlet valves on the smaller machines are of the "Direct-Lift" type; on the larger machines "Hurricane Inlet" valves are standard. "Cushioned Direct-Lift" discharge valves are standard on all sizes. Catalogue shows several views of the machine in section, and gives tables of sizes and capacities.

## Mining Locomotives

The Milwaukee Locomotive Manufacturing Company has issued Bulletin No. 101, devoted to the description of a line of locomotives for mining service, driven by combustion engines using gasolene, alcohol, kerosene, or distillate, and thus making each engine an independent automobile of great convenience and low operating cost. The bulletin is handsomely illustrated, and contains tables of dimensions and performance.

## Gas-Electric Motor Car

The General Electric Company has just issued a very attractive publication devoted to a detailed description of its double-truck type of gas-electric car. The publication is elaborately illustrated, and contains con-



**GAS, GASOLINE AND OIL ENGINES**
By GARDNER D. HISCOX, M.E.
Just issued. Twentieth edition. The book treats on the theory of Gas, Gasoline and Oil Engines as designed and manufactured in the United States. Explosive motors, stationary, marine and vehicle power are fully treated, together with illustrations of their parts and tabulated sizes, also their care and running are included. Electric Ignition by Induction Coil and Jump Sparks are fully explained and illustrated, including valuable information on the testing for economy and power and the erection of power plants. 450 octavo pages, fully illustrated by 351 engravings. Price..................$2.50

**MODERN MACHINE SHOP CONSTRUCTION, EQUIPMENT AND MANAGEMENT**
By OSCAR E. PERRIGO, M.E.
A work of 400 pages, dealing with every problem connected with the building and conducting of a modern factory or shop. The subject-matter embraces the designing of the buildings, the installing of machinery, etc., and the turning out of work. For convenience the book is divided into three parts: The first part deals with the construction and the providing of power, heating and ventilating and lighting; the second part takes up the equipment, both mechanical and administrative, and the third part pertains to management, introducing a simple and efficient time and cost system. Price....................................$5.00

**HARDENING, TEMPERING, ANNEALING AND FORGING OF STEEL**
By JOSEPH V. WOODWORTH
A work treating clearly and concisely modern processes for Heating, Annealing, Forging, Welding, Hardening and Tempering of Steel. The text is remarkably well arranged and illustrated, being of exceptional value to metal-working mechanics, giving directions for the successful hardening and tempering of all steel tools. Price...........$2.50

**PATTERN MAKING**
By F. W. BARROWS, Practical Pattern Maker
This is one of the best treatises on pattern making that has appeared. It is by an author with many years' experience at the bench. There is a general introduction on pattern making as an art, followed by a section on material and tools, taking up subjects like lumber, varnish, hand tools, band saws, circular saws, etc. Then follows a section devoted to examples of wood patterns of different types, and one upon metal patterns. There is then a section upon pattern shop mathematics and one upon cost, care and invention. Price..................$2.00

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Have you an ambitious employee who does?

Have you an employee whom you desire to aid?

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**The Cassier Magazine Co.**

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JOURNAL
OF THE
**UNITED STATES ARTILLERY**

Technical articles of interest to artillerymen, with index to current military literature as supplement

Bi-monthly

Fort Monroe, Va. $2.50

siderable data relative to the subject. It includes plans and elevations of cars of various sizes.

The number of the bulletin is 4855.

---

**Compressors**

"Compressors." — Ingersoll - Rand Company, 11 Broadway, New York City. Form 3109, bulletin of twelve pages, descriptive of Class NF-1 steam-driven, single-stage, straight-line air compressors; twin flywheel, canter crank, enclosed type, with the steam and air cylinders arranged in tandem. Catalogue shows several views of the machine in section, and also gives tables of cylinder diameters, capacities and dimensions. Air inlet valves on the smaller machines are of the "direct lift" type; on the larger machines "Hurricane Inlet" valves are standard. "Cushioned direct-lift" discharge valves are standard on all sizes.

---

"Compressors." — Ingersoll - Rand Company, 11 Broadway, New York City. Bulletin 3007 of 24 pages, descriptive of "PB" power-driven air compressor, duplex type, with the air cylinders close coupled to the frame and a central driving wheel. Catalogue shows several views of the machine in section, and gives tables of sizes and capacities. The distinctive features of this "PB" design are its massive, powerful construction and its simplicity, rugged strength, ample reserve power and unlimited capacity for hard work. The machine is readily accessible inside and out, and is provided with flood lubrication system. Automatic control of the pressure and regulation of output to load are provided by governing devices.

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**Electric Locomotives**

Catalogue No. 11-5, just issued by the C. W. Hunt Company, New York, consists of sixteen pages of text, illustrated by half-tones describing the storage battery locomotives, combination storage battery and trolley locomotives and trolley locomotives they manufacture. There is also a description of their crude oil electric locomotive, built for use where scarcity of water renders the cost of operating steam locomotives prohibitive—in South America, for example, where these locomotives enjoy great popularity.

**Storage Battery Cars**

"Storage Battery cars" is the title of Bulletin No. 13, just issued by the Gould Storage Battery Company, 341 Fifth avenue, New York. This bulletin explains the economics of the storage battery car, describes the standard type made by the Gould Company, and cites the conditions under which storage battery cars can be used most profitably. A copy will be sent on request.

**Inertia Valve Gear**

Bulletin No. 36 of the Bates Machine Company, Joilet, Ill., describes and illustrates the new Bates inertia valve gear, which is now regularly applied to all Bates Corliss engines. This new gear has attracted much attention because of its positiveness and quiet operation and the absence of hooks, springs and rollers.

* * *

Smith, Hauser, Locher & Co. have ordered six storage-battery locomotives from the General Electric Company. The former company has contracted with the city of New York to build a tunnel for conveying the Catskill water supply from about 110th street to Union square. This tunnel will be about 10 feet in diameter, concrete lined, and will be driven through solid rock about 250 feet below the street level. To drive this tunnel expeditiously a series of six shafts will be driven, the distance between two adjacent ones being about one mile. The excavated material will be hauled to the shafts by the storage-battery locomotives and brought from there to the surface by hoists.

**The Santo-Duplex Vacuum Cleaner**

**For Permanent Installation**

OPERATES from ordinary lighting circuit. Can be started or stopped from any floor, without complicated starting devices. Complete equipment for every cleaning purpose furnished with each machine.

**Most Durable and Efficient**
of any stationary plant yet devised.

**Quiet and Powerful**
Continuous suction.

**Easy to Install**
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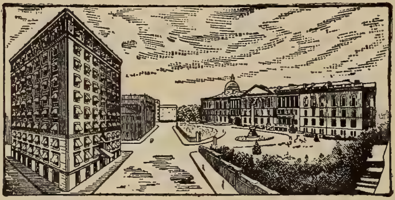

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**THE MAGNIFICENT, FAST, TWIN-SCREW**

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**BERMUDA-ATLANTIC LINE**

**290 Broadway, New York**

# THE HOME PROBLEM IN GREAT CITIES AND HOW ENGINEERING ACHIEVEMENT IS SOLVING IT

By Charles E. Heitman

What's life in the city? There's no room to spare,
Men are crowded in corners and scanted of air;
Too near to be neighbors, too fretful for friends,
Each man jostles each as he seeks his own ends.

There are folk underneath you and folk overhead,
And the noise of the street comes to vex you in
bed:
The jangle of car bells, the cab whistle shrill,
All the hum and the whirr and the dust of the
mill
That is grinding all day and grows louder at night,
Conspire against comfort and banish delight.

Ah, God, for the country—the singing of birds,
The laughter of children, the lowing of herds,
Green grass and blue heavens, bright water, clean
air,
And room enough, room enough, room to spare!
*The Outlook.*

WE are heartily in accord with the sentiment expressed in the above lines. However, when we analyze the question of how best to house the people of our great cities it is interesting to note that it bears such close relation to and is so dependent upon what is mechanically possible that it almost resolves itself into strictly a mechanical problem. Therefore, the hum and the whirr and the dust of the mill are known to be necessary evils to our commercial growth. In fact, the phenomenal growth of our cities has been half the cause and half the

AN INEXPENSIVE SUBURBAN HOUSE AT HUNTINGTON TERRACE, LONG ISLAND, N. Y.

effect of the modern mechanical inventions and achievements, without which the problem of providing comfortable homes for the masses would be impossible of solution.

In our rush for power, place, and material success the momentum of commercial conquest becomes so great that we are swept past the mileposts of progress at such speed that we do not take due notice of those worthy individuals of the engineering world who, through study and expert workmanship, have, in a large measure, conquered the earth, air and sea, and thus made possible the splendid conditions of the present as compared with those of the past.

We cannot conceive how it would be possible to house the ever-increasing number of people who are flocking to our congested centres were it not for our modern methods of transportation, which have brought the outlying country within striking distance of our business centres. Indeed, the development of our suburbs would be wholly impractical were it not for the improved methods of communication, all of which are traceable to the engineer and the mechanic's workshop. The same can be said of the towering office building, the modern apartment house and the fashionable hotel.

The beneficial effects of advanced mechanical thought is felt just as keenly in the real estate and banking world as it is in the manufacturing world, as is evidenced by the numerous corporations which are formed for the exclusive purpose of developing those sections which are convenient to transportation. Many of these corporations are semi-banking institutions, and for the convenience of those who are not financially able to pay all cash for a home or to assume the responsibility of building on their own account these corporations build for them and accept their pay in monthly installments. It works no greater hardship on the individual than the payment of rent.

ATTRACTIVE AND CONVENIENT TWO-FAMILY HOUSE IN THE COUNTRY NEAR LARGE MANUFACTURING PLANT

TYPICAL HOMES OF NEW YORK BUSINESS MEN AT MOHEGAN HEIGHTS, N. Y.

It is, of course, not to be assumed that all of these corporations are operated in strict accordance with approved business methods; but, nevertheless, many of them are officered and managed by men whose reputations are a guarantee of fair and honorable treatment.

It has only been within the past few years that it was possible for a man of moderate means engaged in a city occupation to live in the country with any degree of comfort, but with the improved methods of building and equipping houses, even though remotely situated, it is possible for the day labourer, as well as

(Concluded on page 70.)

HOMES OF EMPLOYEES OF LARGE INDUSTRIAL CONCERN. FRESH AIR AND LIGHT ASSURED

## The Day's Work

THE expression most often quoted in discussions of the labour problem seems to be: "A fair day's wages for a fair day's work." This sounds like a rather plain statement of an obvious fact, and it would be so if both of the fundamental facts involved in it did not seem to be almost entirely indeterminate. Few men are agreed as to what constitutes a fair day's wages, and the subject of a fair day's work seems to be even less settled.

As a matter of fact, the ideas of the day's work and the day's wage have come down from the time when nearly all labour was exerted in agricultural pursuits. Men went to work in the fields and laboured side by side, plowing, sowing, reaping and digging, and the cost of living varied little among them, while the average results of their several efforts enabled the probable return to be fairly well determined.

With the development of diversified industries it became more and more difficult to determine just how much a man could do in any particular occupation, much depending upon the aptitude of the individual and, in recent times, much more depending upon the tools with which the work is done.

The idea that the amount paid should bear a relation to the difficulty or burdensome nature of the work is only partially true, and the entire tendency of modern times is toward the abolition entirely of so-called laborious work, since such results are far better obtained by the use of power-driven machinery, directed by men of higher intelligence, than by the use of a lower grade of human labour.

This is clearly seen in the results which have followed the attempts to increase the results of human energy by the aid of skilled supervision, compared with those produced by the employment of properly designed and operated machinery driven by power.

An excellent illustration of this point is found in the use of the industrial railway, with electrically-operated dump cars, as compared with the handling of bulk material by men and wheelbarrows.

Thus, the capacity of labourers, using wheelbarrows, was raised, under the instruction of a skilled efficiency engineer, from 16 tons per day to 57 tons in the same period of time. This result was attained in moving material in bulk, such as ore, sand, limestone, gravel, and the like.

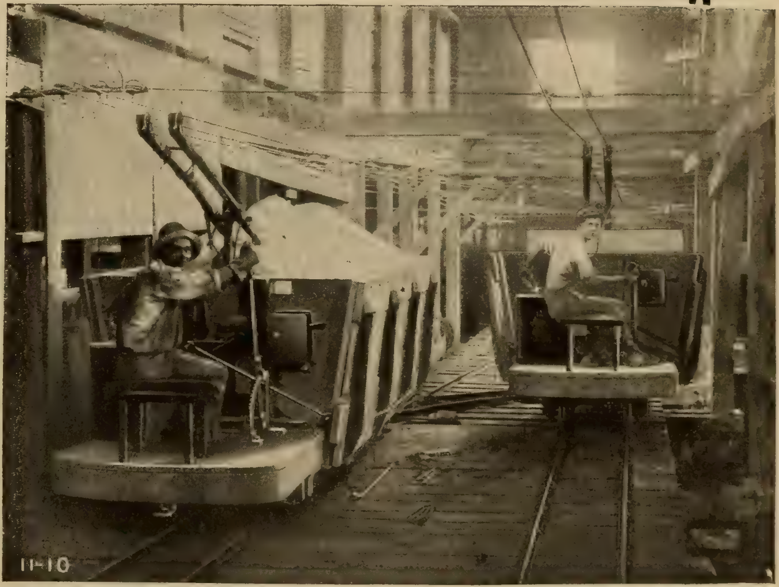
When, however, such work is performed by a mechanical appliance, such as the electrically-operated industrial railway, the work of one man, under adverse conditions, is raised to 50 tons *per hour,* this result including the overcoming of considerable grades and curves, and delivery to points 500 feet distant. Under less severe conditions this performance is readily doubled, while at all times the character of effort expended by the man is far lighter upon his muscles, and involves the exercise of his intelligence rather than his strength.

In comparing the advantages of the use of the machine for such work there must be taken into account the charges for interest and depreciation, but there should also be considered the gain due to the more rapid completion of the job, apart from the mere wage element. The reduction in overhead charges is almost entirely proportional to the saving in time, and this alone is nearly as important as the question of labour cost, while in many instances the emergency value included in the ability to move material in a hurry may pay the entire cost of the installation.

Under such conditions it seems that the use of human muscle should be avoided, when it is possible, as being less efficient, slower, and generally less desirable than properly designed machinery driven by manufactured power.

# Self-Dumping TROLLEY CARS

## for handling Materials in Bulk



"Hunt" Self-Dumping Trolley Cars Handling Fertilizer Materials from Vessels to Storage.
Miller Fertilizer Company, Baltimore, Md.

***THESE CARS,*** while operating under existing unfavorable conditions which do not permit their working at highest efficiency, are each handling, with one man, fifty tons per hour, a distance approximately of five hundred feet, and this capacity is easily doubled when the cars are used under less severe conditions. The track over which they are run includes several seven per cent. gradients and twelve-foot radius curves. Power is obtained from an overhead trolley wire, and the car is fitted with hand brakes and controller.

These cars are made of different sizes and types to meet varying conditions.

We design and install complete equipments for handling fertilizing materials from water front to storage. Write us to-day for Bulletin No. E. 1, and for further information, or apply to our nearest branch office.

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### Scientific Transmission

ONE of the first things which the modern efficiency engineer is obliged to consider when he attempts to plan a system for the improvement of the efficiency of a manufacturing plant is the apparatus for the transmission of the power to the machines by which the work is to be performed. If the transmission, shafting, pulleys, belting and entire equipment are not in proper condition, any attempt to introduce higher speeds, heavier cuts and greater output will be followed by transmission troubles, and the otherwise well-considered plans will be impeded at the start.

Too often these transmission troubles arise because the apparatus for conveying the power to the machines has not been properly considered in the first place. The transmission system is really a machine in itself, falling accurately within the famous Reuleaux definition of a machine, as "a combination of resistant bodies so arranged that by their means the mechanical forces of Nature can be compelled to do work, accompanied by certain determinate motions."

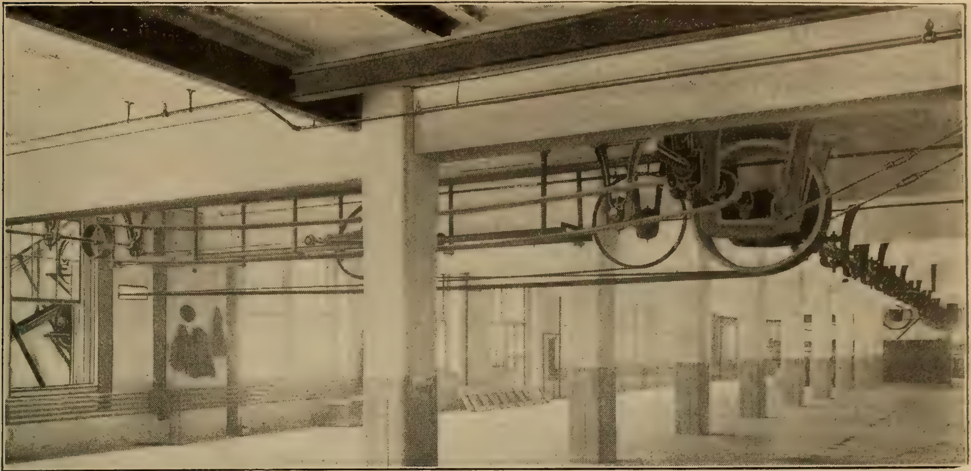
This means that it should have had the same care in its original design as is given to those other machines with which it is combined to form an efficient whole, and it also means that the transmission system ought to be constructed as a standardized unit, in the same manner as any machine tool.

No competent engineer would think of building an operative machine by getting the various parts from different, independent sources, and allowing them to be made without special reference to the character and design of the other parts with which they were to be united. On the contrary, the balance of material, proportion, stress, speed and operative functions is most critically studied, and the modern machine tool is the result of the most careful application of scientific principles.

The moment that the transmission system of a shop is considered itself as a machine it ceases to be a mere aggregation of independently collected parts and becomes subject to the same scientific rules of machine design as should apply to the other tools with which it is associated. This is a very different conception of the subject from the old idea. Instead of getting so many feet of shafting of various diameters and lengths, buying hangers, couplings, clutches, etc., of the same nominal dimensions, picking up pulleys of miscellaneous origin, and having the whole erected by labouring gangs of temporary organization, the modern system involves the preparation of an entire plan of the transmission system, adapted, not only to the immediate work in hand, but having in view the possibilities of future extensions and of increased demands.

There is no difficulty about the production and installation of thoroughly efficient and reliable transmission, since such an undertaking requires simply the same kind of ability and attention as has to be given to the making of any high-class machine. The moment the transmission is considered as a complete mechanical unit, with all its parts standardized and proportioned to be operated with each other, the multitude of difficulties which exist with an ordinary assembled installation disappear. The friction losses may be reduced to a minimum by the employment of standard methods of lubrication, with maintenance of accurate alignment, the delays involved in the installation of new parts, replacement of damaged pieces in case of accident, or shifting of elements to meet changed conditions or additional machinery.

When to such a standardized system of transmission there is added efficient supervision, maintaining a continual inspection of alignment, lubrication, condition of belting, etc., maximum efficiency necessarily follows.



**Standardized Transmission (all Dodge) in the Plant of the Morgan & Wright Rubber Co., Detroit**

**DODGE**

# STANDARDIZED TRANSMISSION
# VS
# ASSEMBLED TRANSMISSION

THE Dodge Idea treats a power transmission system as a complete mechanical unit—a single machine, with every part perfectly co-ordinated—standardized—as far as possible interchangeable.

Dodge Transmission in your factory means a perfect system that will carry a maximum load with a minimum of wear and tear—with a minimum waste of power. It means a system—easy to extend—easily and quickly replaced in case of accident. It means a system—giving every part a lasting full value.

The alternative is an assembled equipment—pulleys bought from one source—clutches from another—couplings from a third. This means lack of balance, a conglomeration of misfits, loss of power, greater wear and tear at every point. It means delay in case of accident, larger loss from depreciation, constant, extra expense.

Dodge equipment is proving its absolute superiority in every point in hundreds of big factories every day.

No transmission system is too big or too intricate for Dodge facilities—no one is too small.

Whether your factory needs run to extra heavy equipment or to ordinary sizes you should know the Dodge Line. It should be your shop standard.

The Dodge Board of Engineering Experts has been organized for the benefit of our customers and factory owners generally. Its members are men of technical training, wide experience and sound judgment. This with their constant association with transmission problems of every nature gives them a wide practical knowledge that cannot but be of benefit to you in meeting your transmission requirements.

These men are at your service. Advise with them on any question of power, economics, distribution, or the standardization of parts. This service is free of obligation.

In addition to this service, and preliminary to it, we have prepared a series of special Dodge books dealing with the transmission problems in all lines of manufacturing. Write us specifically about your requirements. We shall be glad to write you in detail in regard to your particular needs and send you the special Dodge book in which you will be most interested.

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### Skill Promoters

MECHANICS in general are not wanting in respect for personal skill and the achievements of skill, but individually they still are quite apt each to assume that his own trade requires and develops more skill than any other. The machinist, the blacksmith and the moulder, for instance, can each think that he can do and actually does things which for each of the others would be impossible. If it should come to be recognized and appreciated that each is probably correct in his view, the fact should tend to promote mutual respect instead of the reciprocal depreciation which is most familiar.

It may be true in some things that "the looker-on sees the most of the game," but in watching the routine manipulations of workmen in the trades the looker-on cannot really be said to see the true inwardness of the game at all. The one operation of the moulder's trade which has always taken more of his time and strength than any other has been the ramming of the sand in the moulds. The unthinking onlooker can regard this as simply hard muscular labour and nothing more; and in that view of it the invention of the sand rammer was inevitable for the relief of the tired workman.

But to the well-informed the operation of sand ramming in the foundry is one of great responsibility, and the success of the moulder in the trade is never contingent upon the use alone of his muscle in ramming, but upon the judgment—skill's most potent factor—with which it is employed. There is, as the phrase is, ramming—and ramming, and skill is the differentiator. If the requirement were simply to pack the sand in the mould as tightly as possible the task of ramming would be a simpler one and the power rammer might well be made automatic; but, in fact, it is usually most desirable and often very necessary to have the sand packed as loosely as possible, if it will only hold the molten metal to its shape, it thereby retaining some porosity to permit the escape of the gases generated or liberated when the mould is poured. It often happens, also, that some portions of the mould require to be rammed heavier or lighter than other portions, and here the skill of the moulder has a chance to show itself. Foundry experience is full of instances where the successful production of certain castings has been defeated by injudicious ramming, and where later perfect results have been secured by a change in this detail alone.

The heading of this page suggests that the pneumatic hammer is a promoter of skill in the moulder, and it should not be difficult to justify the title. The pneumatic hammer, in the first place, relieves the moulder of the most fatiguing detail of his work and saves more of his energies for the thinking portion of it. This is not an imaginary benefit, for, other things being equal, the man strong in the arm and worked to the limit in that function is not also strong in the head, active in planning for the best results and quick to see the best ways leading to their attainment.

But in the act of ramming the pneumatic hammer does much more than merely to supply the power for the work. It also changes the character of the ramming and gives the moulder a variety of execution in the ramming which his muscles at the best could not command. The force, the direction, and especially the rapidity of the blows, are so completely under the control of the moulder that we might compare the manipulation of the hammer to the playing of a musical instrument, with its legato, staccato, crescendo, diminuendo passages, and all the rest of it.

We thus have, in this simple tool, another example of the manner in which the laborious portion of a task is transferred from the workman to a power-operated machine, reserving for the mechanic the direction of the inanimate tool.

# "CROWN" SAND RAMMERS

More castings and better castings, at less cost—this is the ideal of every foundryman.

**As a first step toward this ideal, install a "Crown" Sand Rammer. It will please you by its work and its staying power — and you will add others as you learn more of its possibilities.**

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### Modern Steel Castings

ENGINEERS who have observed the developments of manufacturing processes for the past score of years have witnessed a remarkable progress in the use of steel as a material of construction. It was to be expected that steel rails would crowd out iron rails, and it was a natural consequence of the success of the art of making steel rails that other structural shapes should follow in a similar material.

When, however, it was attempted to use steel castings for machine elements which had heretofore been forged under the hammer, and in which toughness and freedom from brittleness, blow-holes or flaws of any kind were absolute essentials, only failure was predicted.

At first such views were confirmed by experience, and the uncertainty which accompanied the attempts to substitute steel castings for iron forgings and the irritating delays which unavoidably occurred in filling orders prejudiced many engineers against the use of a material of such an indefinite character.

Nevertheless, the immense advantages which evidently must follow the ability to cast in a mould, from any pattern, however complicated, the parts which demanded the utmost skill of the smith, when made of wrought iron, led to continued efforts to improve the methods; and gradually the production of steel castings of fairly satisfactory character, especially for pieces of moderate size, became commercially practicable.

An important element in the production of satisfactory steel castings is the annealing of the product, and it is upon the care with which this operation is conducted that the character of the product depends.

A well annealed steel casting, made with the experience gained by the practice of the art during recent years, will be found to have an ultimate strength of about 70,000 pounds per square inch under tension, and an elastic limit of about one-half that amount, so that the engineer has at his service a material of wide usefulness.

Even such a material, however, does not meet all the requirements of the constructor, and many large pieces have continued to be made under the hammer rather than in the steel foundry.

With the introduction of the modern alloy steels, however, the scope of the steel casting has been vastly increased, and at the present time even such parts as the main frames of heavy locomotives, as well as cylinders, to stand heavy steam or hydraulic pressures may be satisfactorily cast in steel, provided a vanadium-steel alloy is used instead of the ordinary steel casting.

The ease with which a vanadium steel casting may be made renders this work easy, since the only difference between the manufacture of vanadium steel casting and an ordinary one lies in the addition of a small percentage of ferro-vanadium to the ladle immediately before pouring. Such a small amount as one-fifth of one per cent. of ferro-vanadium will raise the ultimate strength of the material by 10 per cent., while the real point of value—the elastic limit—will be increased as much as 30 per cent. This means that even large castings may be made of vanadium steel which will have an ultimate resistance of 80,000 pounds per square inch and an elastic limit of 45,000 pounds per square inch, and this with no special material other than the ferro-vanadium, and with no modification in furnaces, melting, pouring and annealing over the ordinary practice which gives the ordinary results.

Such products are not limited to size in either direction, as they may be made a few ounces or many tons in weight. The result is due to the material, without change in the process, and the improvement in the material is effected simply by the addition of the element vanadium to the ordinary steel.

# Vanadium Raises the Useful Strength of Steel Castings 30%

Take two ladles of steel for castings, both from the same melt, the same furnace, at the same time.

Pour a casting from one ladle and after annealing it you will get a yield point or elastic limit between 30,000 and 35,000 pounds to the square inch; it will break under tension at about 70,000 pounds.

Add one-fifth of ONE per cent. "Masvan" Vanadium to the other ladle and pour a similar casting and anneal it precisely the same. You will get a yield point around 45,000 pounds, or 30% better; and a tensile strength approaching 80,000 pounds, or over 10% better than the plain steel; the elongation and reduction also being improved by the small addition of Vanadium.

This means that you can cast locomotive frames, high pressure steam valve bodies, hydraulic and steam cylinders and other severe duty machine parts in Vanadium Steel and get Carbon Steel Forging qualities—great toughness, strength, freedom from crystallization and fatigue, and remarkable durability.

Such things are being done every day—results uniform—castings invariably strong, tough and homogeneous. Vanadium steel castings have been made for all kinds of hard services in sizes weighing from a quarter of an ounce up to 20 tons. Put your problems up to a good steel foundry and specify "Masvan" Ferro-vanadium, nothing else.

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### The Need for Better Rails

EVERY intelligent observer who has to travel much by railway must have observed the tremendous increase which has occurred during the past decade in the burden which has been placed upon the rails over which he is transported. The weight of locomotives and of cars has grown beyond all conception of the men by whom the original permanent way was planned, while the increase of speeds has further multiplied the impact forces and stresses to which the rails are subjected.

Although these facts have been apparent to every observer, the consequences have not been so obvious. Occasionally some disaster has been attributed to rail breakage, and for a few days the subject has been featured in the newspapers, but the continual increase in the number of failures of rails cannot be appreciated without an examination of the official records.

According to Chief Inspector Belknap, the accident reports of the Interstate Commerce Commission show that in 1902 there were 72 derailments due to broken rails, while in 1911 there were 249 derailments due to the same cause. In the last decade there have been, altogether, 2,059 derailments caused by broken rails, resulting in 106 killed and 4,112 injured.

It has been considered that some of these defects have been due to rails which were originally imperfect, and contained longitudinal fissures caused by piping or failure to crop off sufficient length of the imperfect ends; but this cannot account either for the number of failures or for the continual increase in the number of disasters.

The investigation of the accident on the Lehigh Valley Railroad in August last is revealing some interesting facts in connection with rail failures which may lead to the true method for the prevention of such disasters. The critical inspection of the broken rail by the experts of the United States Bureau of Standards has shown the existence of a type of defect which has not hitherto been observed, in the form of transverse fissures, apparently due to heavy service, and not traceable to defects in manufacture. These transverse fissures seem to have been caused by the fact that the limit of safe wheel pressures has been passed, and that rails of the present design and material are unequal to the burdens which are being placed upon them.

It is suggested that this involves the necessity for a reduction in wheel loads, and an investigation is suggested to trace the history of a rail from the furnace to the completed track. This is undoubtedly desirable, but at its best it can do no more than place the weaknesses, without indicating the remedy.

That there is a remedy should be definitely asserted, since the increasing roll of disasters renders it imperative that a remedy should be applied. This remedy consists, not in attempting to increase the weight of the rail, because that is well known to be unavailing, but in using a higher character of material. Instead of employing ordinary carbon steel, the limits of endurance of which have been passed, the rail to carry modern wheel loads should be made of an alloy steel possessing greatly increased resistance to abrasion, shock and impact. That this may be accomplished by the use of titanium steel is now well known, since tests have shown an increase of about 20 per cent. in resistance over ordinary rail steel. The comparative behaviour of titanium rails and ordinary Bessemer rails under identical service has been well shown in a previous issue of this magazine, and with the results which have been attained by this inexpensive method of improving the quality of rail steel there appears to be no reason why the increasing list of failures should be allowed to continue. Better rails are undoubtedly needed, and the obvious way to obtain them is to use better material.

# These Eminent Authorities Endorse the Use of Titanium Alloy

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H. Le Chatelier,
Prof. of Metallurgy, University of France.

Simon S. Martin,
Supt. Maryland Steel Co.,

Dr. F. C. Weber,

Dr. R. Moldenke,

Auguste J. Rossi, M.E., C.E.

—and many others.

***Our Booklet No. 31 will tell you what these authorities say of Titanium Alloy. Your competitors have profited by their teachings. Why not you?***

Years ago you were doubtless right in fighting shy of Titanium. But today no maker or user of steel and iron can afford to disregard certain indisputable facts about Titanium Alloy as made by us.

Briefly these are, that Titanium Alloy increases the uniformity and ductility of steels; removes gases and prevents blow holes and brittleness, partially or entirely in proportion to the quantity used. By making steel denser it remarkably increases resistance to abrasion, and power to resist shock or impact. Tensile and transverse strength are improved materially by Titanium, while it gives an astonishing increase in resistance to torsional and compressive strains.

The cost of making such improvement to steel and iron is surprisingly low—for Titanium Alloy is the cheapest high-grade Alloy made.

***We offer to steel and iron makers the services of our metallurgical experts. They will instruct you in the proper use of Titanium Alloy, and demonstrate its efficiency right in your own plant without cost to you.***

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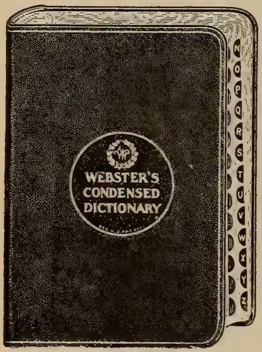

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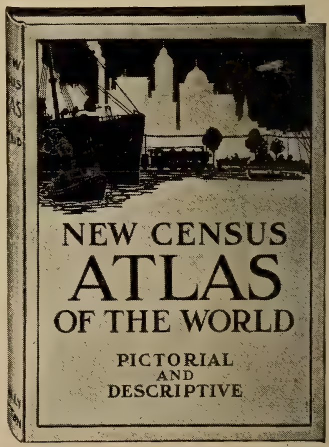

Bound in extra cloth, handsomely and durably bound, size 11 x 15 inches, 200 pages, printed on high grade paper, maps printed in four colors—large, plain and distinct—weight 4½ pounds.

## This Offer Expires January 31st, 1912

**THE CASSIER MAGAZINE CO., 12 West 31st St., New York**

### Three National Motor Car Shows

PLANS completed for the motor car exhibitions to be held next midwinter provide for two national shows in New York and one in Chicago. These are the twelfth annual displays made by the industry to show its progress from year to year. The schedule of dates is as follows:

January 6-13—Passenger Car Exhibition, Madison Square Garden, New York.

January 15-20—Commercial Vehicle Exhibition, Madison Square Garden, New York.

January 10-17—Combined Passenger and Commercial Car Exhibition, Grand Central Palace, New York.

January 27 to February 3—Passenger Car Exhibition, Coliseum and First Regiment Armory, Chicago.

February 5-10—Commercial Vehicle Exhibition, Coliseum and First Regiment Armory, Chicago.

More than two months before the opening date of the first of these national displays a total of 113 different manufacturers of private passenger cars and 86 makers of commercial vehicles were allotted space in one or more of them. Sixty-four of these are new exhibitors, having made no displays at the national shows last winter in New York and Chicago. Of the 64, 39 are builders of trucks and delivery wagons and 25 make pleasure cars.

The Madison Square Garden show will be restricted to members of the old Association of Licensed Automobile Manufacturers and makers of electric vehicles who have been consistent exhibitors at Madison Square Garden for the last five years or more. The Grand Central Palace show will be "open" to all manufacturers, but will not include displays by makers who have exhibits in the Garden. All manufacturers are eligible also for the Chicago show, which is the only one that will be held in that city, and it will include exhibits by most of the makers who display at both the New York shows.

The show committee for the display in the Madison Square Garden consists of Messrs. George Pope, Charles Clifton and Alfred Reeves, with M. L. Downs acting as secretary.

The show to be held at the Grand Central Palace will be, for the first time, under the auspices of the National Association of Automobile Manufacturers, and will be under the management of Mr. S. A. Miles, who has conducted the Chicago show for more than a decade—in fact, ever since such shows were inaugurated—while the Coliseum show in Chicago will be under N. A. A. M. auspices and Miles management.

---

Mr. Bruce W. Benedict, for several years in the motive power department of the Atchison, Topeka & Santa Fé Railway, has been appointed director of the shop laboratories in the Department of Mechanical Engineering at the University of Illinois.

Mr. Benedict was born in Buda, Ill., in December, 1876, graduated from the University of Nebraska with the Class of 1901, and served an apprenticeship on the Chicago, Burlington & Quincy Railroad prior to entering college. After graduating he occupied successively on the same railroad the following positions: Machinist, assistant in testing laboratory, assistant road foreman of engines, road foreman of engines, general foreman of locomotives and car repair and mechanical inspector. He left the Chicago, Burlington & Quincy Railroad Company to become an editor of the *Railway Master Mechanic*, of Chicago, a position which he held for two years, and then became supervisor of schedules on the Atchison, Topeka & Santa Fé Railway, and still later bonus supervisor on the same road, which position he will give up before the first of the year to assume the duties at the University of Illinois to which he has been appointed.

### The Home Problem in Great Cities

(Concluded from page 57.)

the millionaire, to enjoy the healthy pleasures of country life.

It is to be assumed that all right-thinking men and women desire a home, and that nearly all of us would prefer to be owners rather than tenants. The word home conveys to most minds a place definite, permanent and lovable, and we could not conceive of such qualities surrounding rented homes. Men of families should be especially grateful for the opportunity to get away from box-like streets with box-like flats and apartments with which they are confronted when looking for an abiding place in the congested sections of our great cities.

In selecting a home there are two distinct questions to be considered. First, the home as a place of residence, and second, the home as an investment. When considering the first question the matter of local environment is of the greatest importance. As to the investment side of the home proposition, it is a fact generally conceded that land anywhere within a reasonable radius of our growing centres of population will, sooner or later, feel the effect of the metropolitan character and reflect this advantage by steady, sure increases in valuation. If due discretion is used in selecting a location for a home, there is no doubt but that it will prove a better investment than depositing money in banks at a low rate of interest.

Many of our largest manufacturing enterprises have seen the wisdom of moving their plants to the country and incidentally aiding their employees to develop home colonies. This method is not only helpful to the employees and their families, but it is equally helpful to employers, as it promotes happiness among their men and makes strikes and dissatisfaction less likely. It is to be hoped that this example will be followed by many others, as we believe it is the sanest and surest method of solving the home problem and materially benefiting the labour situation in our congested commercial centres.

### New Motor-Driven Ocean Steamers—Two for the Hamburg-American Line to be Completed Early in 1912

Recent advices received from England call attention to the great progress being made in the construction of combustion motor-driven ships, twelve ocean-going vessels of that type at present being under construction, and plans prepared for a vessel of 14,000 tons, which will be fitted with internal-combustion engines.

Two large motor-driven vessels built for the Danish East Asiatic Company have been launched within a short period, and it is expected that the two motor liners of about 6,000 tons now under construction on the Elbe and Weser for the Hamburg-American Line will be ready early in 1912.

The machinery space in this type of vessel is only about one-third of that required for steam engines, thus affording much greater room for cargo and passengers, while there will be an entire absence of smoke and the dirt caused by coaling.

The fumes from the engine room are to be led up inside one of the masts and exhausted 48 feet above the deck, which means the absence of smokestacks on these vessels.

Greater carrying capacity and much less time consumption in starting the engines are strong points in favour of this class of motive power.

### Safety Devices in University of Illinois

All the wood-working machinery of the shops of the University of Illinois has been equipped with safety devices, the object being not only to safeguard the students and employees, but to furnish an exhibit of the most improved forms of such devices. Several of the safety devices have been designed and built in the shops.

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# BRISTOL'S FRICTIONLESS INK TYPE RECORDING INSTRUMENT

An illustrated description of Bristol's patented semi-transparent smoked chart recorder has been previously published, and, although these recorders are fundamentally simple in their construction and hundreds are in daily service, there has been a call for a recorder in which the record is made with ink. To meet the demand for a frictionless ink type recording instrument to parallel the smoked chart recorder as nearly as possible in fundamental simplicity and to accurately record fractions of millivolts and adapted for use as a recording electric pyrometer, the instrument illustrated herewith has been developed and placed upon the market by the Bristol Company, of Waterbury, Conn.

These instruments have been thoroughly tested out in practical service for two years past, and are the result of several years of study and experience with an original* patented design of the frictionless ink recorder using a hinged electrical movement carrying a retaining receptacle for marking fluid which extends over the path of the recording tip and is provided with means for periodically making contact with the source of marking fluid and the chart.

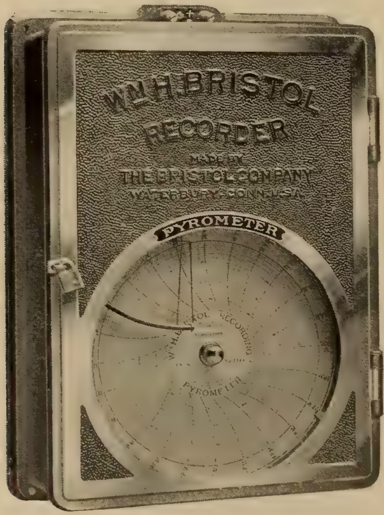

FIG. 1

Fig. 1 shows the recorder ready for operating.

Fig. 2 is an interior view showing the galvanometer movement case hinged to the back of the instrument and carrying the inking pad in front of the recording arm.

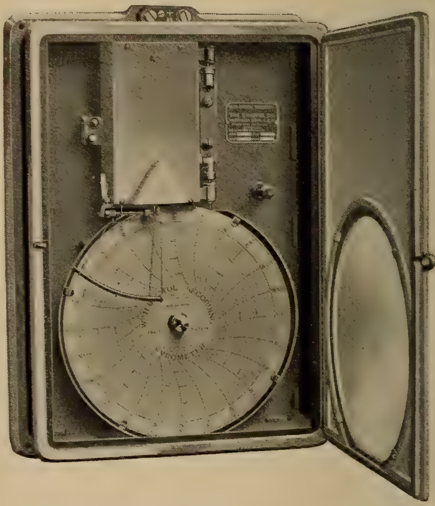

FIG. 2

Fig. 3 shows the sensitive electrical movement swung to one side for convenience in removing the record and inserting a fresh chart. A capillary gold tube, open at both ends, is carried at the end of the recording arm at right angles to the surface of the chart. The inking pad is suspended from the case of the electrical movement, and is curved to correspond with the arc covered by the motion of the end of the recording arm.

When the movement is swung back into its operating position, as shown in Fig. 2, the recording arm can swing free, accommodating itself

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* Patented by Wm. H. Bristol, April 13, 1909.

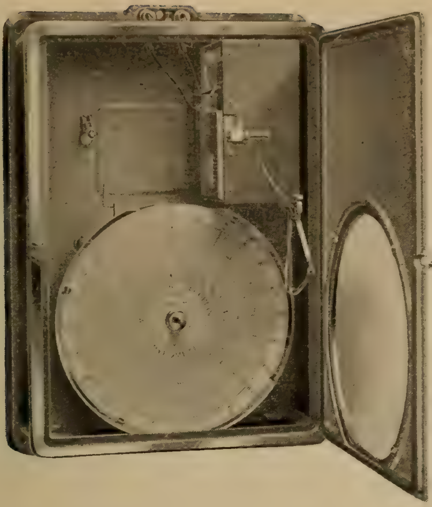

FIG. 3

to the position corresponding to the delicate current which is to be measured. The clock which revolves the chart at the desired speed also automatically presses the inking pad toward the chart every ten seconds, bringing one end of the capillary tube into contact with the chart and the opposite end simultaneously into contact with the inking pad. A fine dot of ink is left on the chart, and the capillary tube is replenished with ink from the pad. The recording arm thus carries a constant supply of ink, and its perfect balance, which is very important, is always maintained. The electrical movements used in these recorders are made especially for the purpose by the Weston Electrical Instrument Company.

Although the most important applications of these recording instruments have been for pyrometers, they have also been used for electrolytic research, recording voltmeters and recording shunt ammeters.

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Is the new Suction Sweeper just added to our line of Santo Vacuum Cleaners.

It embodies a number of new ideas and improvements of our own, making it more efficient than any other suction sweeper now on the market.
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Send for Booklets describing our various types of Cleaners

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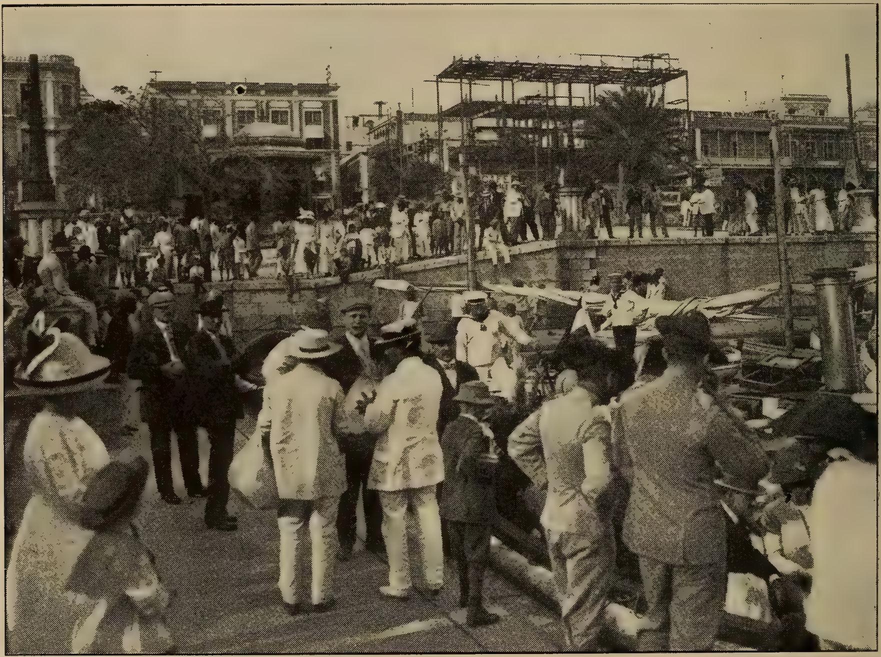
Dept. C **Phila. Pa.**

# THE STEEL GIRDER FOLLOWS THE FLAG

By M. B. Cea

American methods are working a gradual industrial revolution throughout her colonial possessions. The new influence is especially marked in Porto Rico, where contrast is invited with the deliberate, easy-going life of the tropics. A striking object lesson of the new régime is afforded by the appearance of the waterfront at San Juan. Here the low skyline of the ancient Spanish buildings has been suddenly broken by a modern, up-to-date American building.



AMERICAN STEEL BUILDING CONSTRUCTION AT SAN JUAN, PORTO RICA

The builders have employed steel construction—a common enough sight throughout the United States—which, nevertheless, appears unusual in this foreign setting. The new four-story building appears almost a skyscraper in comparison with the low, two-story structures which surround it. Then, again, the plan of raising a building to its ultimate height before the walls are commenced introduces an entirely new element into this tropical street scene. The accompanying photograph was taken during the embarkation of the tourists who visited the island on the S.S. *Moltke*, of the Hamburg-American Line, on one of its regular winter cruises. The scene is characteristic of the tropics—the white clothing worn both by men and women, the brilliant sunlight and the luxurious palm trees growing in the city streets. Meanwhile, the strident racket of the riveters adds a new note to the usual quite of the old tropical city.

# FINANCIAL NOTES

$ A department of information on industrial and other securities of value to investors and men of affairs. $

$ $

## OF THE INDUSTRIAL WORLD

**SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible, the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.**

**CHARLES EASTON, Financial Editor.**

### The Situation

THE business situation has undergone a change for the better during the past month, and there is no good reason why the improvement should not continue.

The expected has happened to the United States Steel Corporation, and, regardless of the merits or demerits of the Government's position, the fact remains that the whole business world has felt a sense of relief since definite action was taken.

Business conditions cannot rise above the thought that governs them. Therefore, it naturally follows that when fear, doubt and uncertainty are removed as to any important procedure involving commercial affairs a betterment in general conditions must be the result.

The period of political and commercial reconstruction through which the country is now passing will, in our judgment, prove a decided benefit to all classes, if for no other reason than the fact that it has brought out the necessity for business statesmanship rather than political leadership; and, what is equally important, it has uncovered evidence that has convinced the investing public of its folly in buying speculative securities without regard to their intrinsic worth.

Many Wall Street houses have been slow to appreciate this awakening on the part of investors, with the result that they are still making strenuous but ineffective efforts to interest the public in the speculative side of the market.

Gambling in Wall Street securities by the man of small means has practically ceased, and the passing of this disease is one of the healthy signs of the times.

Since the last issue of this magazine there has been a serious break in the New York financial markets, and likewise an important recovery has followed. The unsettlement in the stock market has been confined largely to the industrials, because of the fact that special events have occurred to disturb the industrial companies. This, combined with the declining margin of profit on many industrial operations, has generally weakened the security market.

While the situation regarding stocks has been somewhat a dubious one, it is encouraging to note that the rails have held their own, even in the face of light earnings, as compared with the showing made a year ago. Progress is being made by the managements in the matter of regulating operating expenses to the new conditions imposed by the Interstate Commerce Commission.

Reviewing the market outlook from rather a general standpoint, without taking into consideration many important factors, we feel justified in saying that railroads are nearing the proverbial turn in the road, with improvement assured, while many of the large industrials have prospects of a rough journey ahead of them unless they devise some means of complying with governmental requirements.

*Question*—What do you think of United Fruit Company's stock?

*Answer*—The stock of the United Fruit Company, which is dealt in on the Boston market, is regarded favourably. It pays its dividends regularly, and occasionally declares an extra dividend.

While the Bulls chuckled over the opinion of the Interstate Commerce Court in the railroad rate cases, the Bears gloated over the decision ousting the International Harvester Company from the State of Missouri, on the grounds that the company had violated the anti-trust law of that State. This action of the Missouri authorities caused a break in Harvester common.

The Jeffrey Manufacturing Company, of Columbus, Ohio, manufacturers of mining, elevating, conveying and power transmission machinery and coal mine equipment, have recently opened another branch office at 1201 American Bank building, Seattle, Wash., from where they will handle their business in the Northwest.

Mr. Percy E. Wright, their Seattle manager, is a sales engineer, having been connected with their home office for the past ten years, and is thoroughly conversant with the conditions in the Northwest territory, having been traveling in that part of the country for a number of years.

The Jeffrey Manufacturing Company are maintaining thirteen branch offices in the United States, as well as nearly one hundred agencies in the leading commercial centres all over the world.

The *Iron Age* announces the arrival of the rail-buying season for 1912. Rail buying for 1912 has recently begun in earnest. The Louisville & Nashville placed 50,000 tons with the Ensley mill, and the Burlington has ordered 20,000 tons of open-hearth rails from Gary. The Norfolk & Western order, amounting to 25,000 tons, has been distributed among Pennsylvania and seaboard mills. The Great Northern is expected to buy 40,000 from the Buffalo mill. Substantial buying is also anticipated from Southern roads. It is also reported that the New York Central and Pennsylvania are negotiating for a large tonnage.

*Question* — Does the Debenture Corporation of New York confine its business to real estate, and are its bonds regarded as a safe investment?

*Answer*—The business of the Debenture Corporation of New York is confined to real estate, and we regard its bonds as a safe, dependable investment.

It is reported that a great part of the loan of $13,000,000 which E. H. Brown, president of the National Railways of Mexico, who has recently visited New York, negotiated on behalf of that company, will be used to construct important extensions to the system. Surveys and preliminary arrangements for a general expansion of the property have been made.

The Canadian customs authorities recently issued an order putting into effect the "Anti-Dumping" clause of the tariff with respect to a certain class of steel tubing made in the United States. The order was made as the result of complaints by Canadian tube makers that the United States manufacturers were dumping their product on the Canadian market.

Census reports show 9,968,172 bales of cotton ginned from the growth of 1911 on November 1, compared with 7,345,953 in the same period of 1910.

The great oracle from the Northwest, Mr. James J. Hill, was rather non-committal on his recent visit to New York. He was sure, however, that business was better, and he gave New Yorkers a splendid bit of advice when he told them to visit the land show at Madison Square Garden and see for themselves what this great country was capable of producing in the way of farm products. It was particularly interesting to note the display from the Southern States, especially Texas.

The Berkshire Street Railway Company, of Pittsfield, Mass., is making very extensive additions and alterations to their old "East street" power station at Pittsfield. This work involves the tracks, lines and stations, and the supplying of additional power for both the old and the new stations.

Realizing the manifold economical advantages of securing additional power by the use of low pressure steam turbines operating in conjunction with reciprocating engines, this company has placed an order with the Westinghouse Machine Company, East Pittsburg, Pa., for two 750-kilowatt, low-pressure steam turbines driving three-phase, 25-cycle, 375-volt, A. C. generators.

The old equipment consists of two 1,200 horse-power Rice & Sargent reciprocating engines running at 96 revolutions per minute direct connected to two 750-kilowatt alternators.

*Question*—What dividend is paid by the Ontario & Western?

*Answer*—Ontario & Western is paying 2 per cent. a year. It looks like an attractive purchase, because it is known that the New Haven

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**34th Street and 8th Avenue**
**NEW YORK, N.Y.**

**Capital - - - $200,000.00**
**Surplus and Undivided Profits $196,000.00**

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**Prompt remittances made on all drafts sent us for collection.**

**SAFE DEPOSIT VAULTS**
**Boxes $5.00 per year up**

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*Your account is solicited.*

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paid something like 45 for the stock when it secured majority control.

---

Judge Knapp, of the United States Court of Commerce, recently stated to the University of Pennsylvania that rebating is now as rare as forgery. The next morning, however, the United States Grand Jury, of New York City, filed thirteen indictments for rebating against railroad men and shippers of the city.

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Reports of forty-nine of the country's leading railroads, operating about 147,000 miles, or nearly 60 per cent. of the railway mileage of the United States, for the month of August, 1911, show a total decrease in gross earnings equal to 1.22 per cent., as compared with those for August, 1910.

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The American Telephone & Telegraph Company has assumed more direct control over the companies in which it owns a controlling interest, with a view of benefiting the company's service and, at the same time, increasing its earning capacity.

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It would seem that the merging of the elevated lines, surface roads and electric lighting and power companies of Chicago was practically assured. The co-operation of the city has been asked in the effort to consolidate the surface and elevated lines. All the properties being considered are now in fairly good shape, both physically and financially. Mr. Samuel Insull, one of the most successful public utility men of the country, is one of those in charge of the negotiations.

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*Question*—Would you advise selling Great Northern ore certificates?

*Answer*—We consider it wise to hold your certificates for the present and await developments. Naturally, they are wholly speculative, but many factors are to be taken into consideration. It is difficult to arrive at the intrinsic value of these certificates. It was originally figured that each ore certificate was worth approximately $37. However, the development work of the Steel Corporation may greatly enhance this value.

The United Railway of Detroit has at last given in to the public's demand and granted three-cent fares and universal transfers. It is to be hoped that this does not mean poor service or bad equipment, as has been the case in other places where it has been tried.

It is reported that the earnings of the independent steel companies will show a decrease this month. The earnings of the United States Steel Corporation for the current quarter are estimated at between $20,000,000 and $22,000,000. At present steel prices it is stated that many of the independent companies are not earning more than $1 a ton on the average. It is because of this low basis that manufacturers feel certain that prices are bound to improve from now on. Inasmuch as the Steel Corporation is making no efforts whatever to sustain the steel market, any trade improvements must be accredited to the equipment buying by railroads.

The prices for copper metal have become somewhat firmer. The demand for the metal from abroad is fair, considering the recent heavy buying movement. The report of the Copper Producers' Association should be favourable, although developments will have to be made against an increased refinery output.

It has been rumored that the Pennsylvania Railroad would issue $100,000,000 of 4 per cent. collateral bonds. It may be stated, however, on good authority that the Pennsylvania does not contemplate any new financing in the near future. It has now a surplus of something over $40,000,000 in its treasury.

The report of the General Motors Company shows net profits for ten months amounting to $4,447,146. President Neal says: "Factories now are in practically full operation, and the outlook for the current year is excellent."

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**You Can Arrange For Such A Man At Reasonable Expense**

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**H. C. HORTON**
**50 Pine St., New York**

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Your advertising should so link up with your selling policy as to produce **actual sales.**

We have studied the proposition of sales plans and distribution, the tactful route from the manufacturer to the purchaser, holding and using the good-will and power of the retailer; welding them all into a strong, powerful force to move your goods.

¶ Write and let us work with you on *your* proposition.

**Maclay & Mullally Bros.**
General Advertising Agents

Distribution and Sales Plans

**60 Broadway, New York**

# EMPLOYERS' LIST

*Advertisements of positions seeking men, or men seeking positions, are inserted under this heading at the following rates.*

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| One inch, single insertion - - - - - - - | $1.00 |
| Each additional inch in same issue, up to 4 ins. | .85 |

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| One inch, single insertion - - - - - - - | $1.35 |
| Each additional inch in same issue, up to 4 ins. | 1.20 |

Special rates for definite amount of space contracted for to be used as desired during one year, and not more than four inches in any one issue.

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**A Large Manufacturer near New York requires a young man with experience in machine shop, must be good draughtsman and familiar with printing machinery. Salary, about $30 a week. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., Agency, 149 West 35th Street, New York, N. Y.**

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Successful salesman (28), with both office and outside experience desires position in sales department with opportunity to increase the efficiency of the department. Office Service Company, 50 Pine Street, New York. An agency for high-class people.

---

Successful Teacher of Italian with highest New York references, can arrange to give a few more private lessons. Terms reasonable. "Tuscan," care Cassier's Magazine.

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A Large Corporation near New York desires a Technical Graduate with experience in elevator, conveyor and structural steel design. Salary about $35 per week. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., Agency, 149 West 35th Street, New York, N. Y.

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## EMPLOYERS' LIST
(Continued)

**WANTED—MECHANICAL ENGINEER, for Packing Company in New England. Must have a thorough knowledge of mechanical motions with view to designing new machines. Experience with modern conveying machinery desirable. Must be willing to assist in accounting department during rush season. Man who has experience with sterilization problems or rudimentary knowledge of bacteriology will be given preference.**

**Employers' Guarantee Co., Agency, Douglas & Hall, Proprietors, 149 West 35th St., New York City.**

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WANTED—By architect in New York, draughting and designing for evenings. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., Agency, 149 West 35th Street, New York, N. Y.

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A young man with four years' business experience wishes a position as salesman or New York City representative for some reliable concern, who will appreciate a good, hard worker, and will offer advancement. Address 101, care Cassier's Magazine.

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Translator of French, Italian and Spanish, expert and experienced, desires temporary or permanent work in or near New York. Address "Translations," care Cassier's Magazine.

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**The American Manufacturer who desires to introduce his goods in Italy, can obtain high grade representation by an engineer with American business experience, residing in Italy and engaged in the introduction of articles of American manufacture in that country. There is, at present great demand for many articles of American invention and manufacture in Italy. "Italy," care Cassier's Magazine.**

***Employers' List continued on next page***

# EMPLOYERS' LIST
(Continued)

**Strong Stock Company now organizing, wishes preliminary correspondence with firms who desire South American representation. Exporting or importing. High financial standing. Address R. A. Hall, 149 West 35th Street, New York, N. Y.**

A firm requiring either part of the whole time of a man for their foreign correspondence, can, by addressing the undersigned, secure the services of a young man with university training, speaking fluently French, Spanish, Italian and English, New York or near-by preferred. Will accept small salary to start. Best references. "Foreign Correspondent," care Cassier's Magazine.

**WANTED—By Civil Engineer, Technical Graduate, position with Civil Engineer as assistant, with view to obtaining interest in business. Expert on lot location, topographical draughting and hydrographic work. Employers' Guarantee Co., Agency, Douglas & Hall, Proprietors, 149 West 35th St., New York City.**

**WANTED—By Mechanical Engineer, in New York, draughting for spare time. Specialty: design of tools for interchangeable machinery. Kindly mention Cassier's Magazine when replying. Employers' Guarantee Co., 149 West 35th Street, New York, N. Y.**

**MECHANICAL ENGINEER, graduate of technical school, wishes position preferably in sales department. Eight months shop experience, six months in advertising and sales department of large manufacturers. No position without opportunity of advancement considered. Employers' Guarantee Co., Agency, Douglas & Hall proprietors, 149 West 35th Street, New York, N. Y.**

ELECTRICAL SALESMAN wishes position to call on trade in New York or suburban towns, has had practical experience in manufacturing. Employers' Guarantee Co., Agency. Douglas & Hall, proprietors, 149 West 35th Street, New York, N. Y.

Display being debarred here, the use of the space must take its place. Correct copy can cut cost considerably in advertising. If the story is right, the title need not be a sign. Plain-Ad Man, care of Cassier's Magazine.

# Foreign Markets for American Products

## Plan for Placing on File in every American Consulate a Complete Card-Index Catalogue of American-made Goods.

*Extracts from a speech made in Congress, May 4th, 1911.*

"Every manufacturer of the country is permitted to have a brief of his catalogue prepared on cards for classifying and filing in card-index files, in the various commercial languages of the world, without any cost or fee other than the cost of printing and preparing his cards for these files.

"This plan of providing full information respecting every line of goods produced in America in the languages of the various countries in such shape that every foreign buyer may have this information not only at any American consulate, but such portion of it as his individual requirements demand, in his own office at the cost of postage in mailing it to him, is the completion of an almost perfect system in developing our foreign trade.

"Think of the result to our foreign trade if any foreign merchant in any part of the world can step into the nearest American consulate and consult a file in his own language that will give him full and accurate information respecting every line of goods manufactured or produced in the United States, and then have a duplicate of each portion as he may wish of these files placed in his own office for his constant use.

"This work is undertaken by a private concern, for the reason that the special and individual service to each manufacturer and the distribution of this information to individual buyers is a work that is manifestly outside the domain of a government office. This private organization is the Commercial Bureau Co., which has made an offer to the Department of State to equip all American consulates with a system of card-index files containing complete digests of the catalogues of all manufactures of the United States free to the manufacturers. The Department of State has therefore given the Commercial Bureau Co. the privilege of placing these files in each American consulate.

"Any manufacturer desiring to take advantage of this free service in the consulates must communicate direct with the Commercial Bureau Co., 50 Church Street, New York.

"The advantages of this publicity should be very great to all American manufacturers in all lines, and this arrangement should be studied with care by them."

# BOOK NOTES

## The Changing Chinese

The Changing Chinese. By Edward Alsworth Ross, Ph.D., LL.D. Over 100 illustrations from interesting photographs; 8vo; 350 pages. Price $2.40 net, postage 18 cents. The Century Company, New York.

In view of the recent happenings in China this book, written on the basis of six months' travel in China by the author, Professor Ross, who is the first sociologist of adequate modern equipment to seek the keys to the interpretation of Chinese society, is most timely and interesting reading, and is the first pronouncement on the subject by a competent representative of the young and ambitious science of sociology.

Unlike the business man, who traces the ills of China to industrial backwardness; the missionary, who traces them back to lack of true religion; the diplomatist, who assigns them to a medieval government, or the ethnologist, who traces them to race failings: Prof. Ross finds their ills root chiefly in certain peculiarities of Chinese social organization. He holds, among other important points,

> The race mind of the Chinese is not appreciably different from our own, and their so-called "race traits" are what we would probably show if we had been subjected to their circumstances and historical development.
>
> The oft-praised solidarity of the Chinese family, far from being a source of strength, has so stimulated multiplication as to make China the theatre of the direct struggle for subsistence to which any civilized people has ever been subject.
>
> By extensive inquiry among physicians in China he has established that the menace of the coolie's competition with the white labourer is not the coolie's superiority in efficiency, but the greater tolerance of his physique to coarse food, contaminated water, bad air, fatigue poison and noxious microbes. The yellow labourer can *underlive* the white, but not *outdo* him.

In fact, Professor Ross is inclined to stress social environment rather than heredity, to explain national character in terms of social history rather than of race, and to look to economic factors for interpretation rather than to philosophical ideas. He lays great stress upon swiftness of contemporary social development, and is a leader in inciting public opinion to catch up with actual society. He feels that, in a tumultuous dynamic epoch like ours, the chief danger is lest adjustment in laws and institutions be made tardily, and only after a needless interval of acute suffering.

Born in the Middle West, left an orphan at nine, with only the opportunities of a district school, Professor Ross worked his way through college and graduated at nineteen. At twenty-one he went abroad and spent a year and a half studying philosophy at the University of Berlin and traveling. He studied political economy at Johns Hopkins University, receiving the degree of Ph.D. in 1891. He was a professor at Stanford University for seven years, University of Nebraska for five years, and also a professor at the University of Wisconsin for a like period. During 1898-99 he was lecturer at Harvard and the University of Chicago, and has traveled extensively.

Both by study and training Prof. Ross is well fitted for the work undertaken. His book deals with all the important relations between China and the West, while his conclusions are positive and novel and supported by a wealth of facts. It is a book of interest for the general reader, as well as for the student, in its picturing of Chinese life and customs.

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## The Copper Handbook, Vol. X

Vol. X., The Copper Handbook, by Horace J. Stevens. 1902 pages, 1,500,000 illustrations. Horace J. Stevens, publisher, Houghton, Mich. Price $5.00 buckram binding, $7.50 full morocco. Sent prepaid to any address without advance payment, subject to return after a week's inspection.

VOLUME X., the tenth annual edition of The Copper Handbook, is just received. The new issue of the work, which is considered a standard authority on the subject of copper and copper mines for the entire globe, has 1,902 octavo pages, containing nearly 1,500,000 words, and, in addition to the miscellaneous chapters, lists and describes 8,130 copper mines and copper mining companies in all parts of the world, this being the largest number of titles ever listed by any work on mining. The descriptions range from two or three lines in the case of dead companies, wherein reference is made to detailed descriptions in past volumes at the period of their activity, up to 21 pages in the case of the Anaconda mine, which yields one-eighth of all the copper made in the world.

The miscellaneous chapters of the book, twenty-four in number, treat the subject of copper from all possible viewpoints, there being chapters on the history, chemistry, mineralogy, metallurgy, brands and grades, alloys and substitutes for copper, with a copious glossary and a chapter of statistics ending the book that contains forty-odd tables thoroughly covering copper production, consumption, movements, prices, dividends, etc. The Copper Handbook is sold on the unique plan adopted nine years ago, the publisher sending the book by mail, prepaid, to any address ordered, without advance payment of any sort, and subject to return after a week's inspection. The price is $5 in a strong green buckram binding with silk headband and gilt top, or $7.50 in full library morocco. Anyone interested in copper, as a producer, consumer, or investor in shares, would do well to write the author and publisher, Mr. Horace J. Stevens, Houghton, Mich., ordering a copy of the new Copper Handbook sent prepaid, subject to approval.

### The Water Supply of a Great City

BY J. F. SPRINGER

The Cameron Steam Pump Works report an exceedingly prompt and large demand for copies of the booklet just issued by them entitled "The Water Supply of a Great City."

This pamphlet contains about 70 pages of text, very fully illustrated by half-tones, and is a most interesting and valuable record of the extensive engineering work which has been accomplished in the construction of the Catskill Aqueduct, built to furnish America's largest city with a sufficient supply of water.

THE MOST ILLUMINATING
BOOK ON THE CHINESE
PEOPLE EVER PUBLISHED

**The Changing Chinese**

By

**EDWARD ALSWORTH ROSS, Ph.D., LL.D.**

*Professor of Sociology in the University of Wisconsin and author of "Sin and Society," "Social Control," etc.*

THE first presentment, by a sociologist of adequate modern equipment, of the conflict of Oriental and Western cultures in China.

An interpretation of Chinese society by the method of first-hand observation — Professor Ross declares, and gives his reasons, that the race mind of the Chinese is not appreciably different from our own.

A vivid and fascinating picturing of Chinese life and customs, and so a book of extraordinary interest for the general reader as well as for the student. The volume has over one hundred illustrations from photographs which really illustrate, and reproductions of some interesting Chinese cartoons.

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Union Square, New York

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There are detailed instructions for building fifteen of the newest models, with a special chapter devoted to parlor aviation, full instructions for building small paper gliders, and rules for conducting model aeroplane contests.

***The illustrations are from interesting photographs and helpful working drawings of over one hundred new models.***

*The price, $1.20 net, postage 11 cents*

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THE BOYS' BOOK
OF MODEL
AEROPLANES

It tells just how to build a "glider," a motor, monoplane and biplane models, and how to meet and remedy common faults—all so simply and clearly that any lad can get results. The story of the history and development of aviation is told so accurately and vividly that it cannot fail to interest and inform young and old.

***Many Helpful Illustrations***

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Published by
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Union Square NEW YORK

The pamphlet reviews the entire problem of a water supply for New York from early times to the present, and contains matter of interest to every engineer.

When it is realized that upon the entire completion of the Catskill project New York will have a daily water supply of one billion gallons, thoroughly distributed over an area of 309 square miles and supplying an average quantity of nearly one pint of water daily for each and every square foot of surface, the vastness of this great work which is being successfully brought to completion will be realized.

Those desiring a copy of this valuable pamphlet should write promptly to the A. S. Cameron Steam Pump Works, foot of East Twenty-third street, New York, mentioning CASSIER'S MAGAZINE, so that a copy may be sent them.

### Employers' List

Owing to the fact that we are constantly receiving letters from firms, who have positions open, asking if we can suggest satisfactory men to fill them, we decided to insert a Classified Advertising Department in CASSIER'S MAGAZINE. Under the heading of "Employer's List" this appeared for the first time in November and carried advertisements, both of positions requiring men and men seeking positions. The results thus far have been such as to make us feel certain that both employers and men seeking employment will find this new department of positive value.

**Do You Want Expert Help?**

**See Advertisements in Employer's List in Cassier's Magazine**

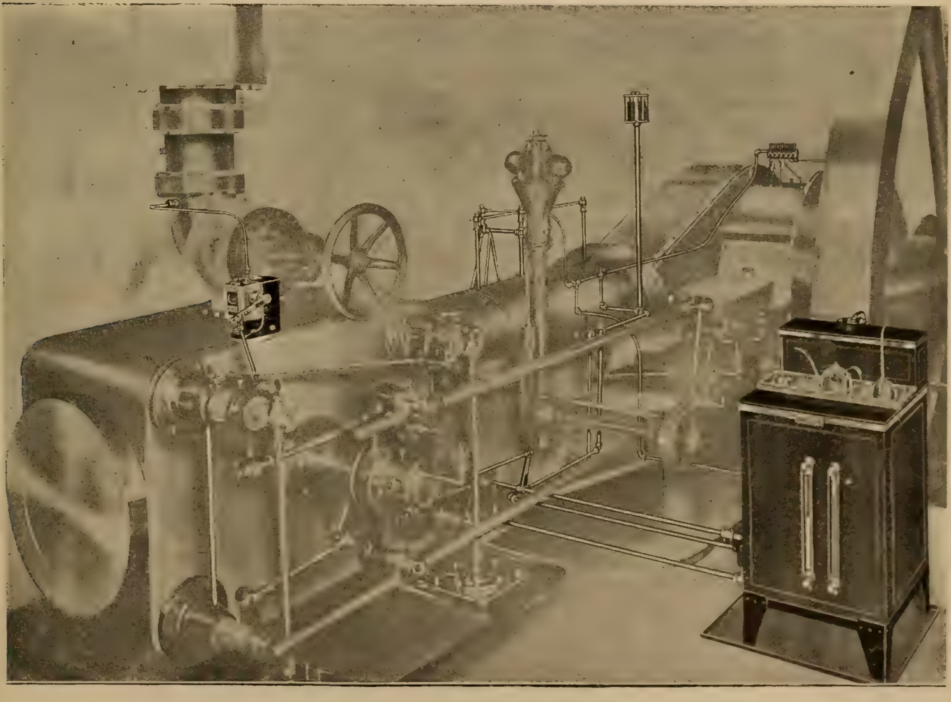
# A NEW DEPARTURE IN ENGINE LUBRICATING SYSTEMS

PRACTICALLY all engineers now realize the economy in oil and steam due to the use of an efficient lubricating system on their engines and auxiliaries. For some time engines in the large railway and lighting power plants have been provided with automatic systems for bearing lubrication. These systems are usually of the central type, in which oil is supplied from a central source and passed through pipes to all of the bearings on the different power units and their auxiliaries. The drips from the bearings are collected and returned to a large central filtering plant, and, after impurities are removed, the oil is recirculated. While this system is admirably suited to large stations, it is not so well adapted to the ordinary small isolated plant, because it is too expensive, and the large amount of piping it requires (a large proportion of which has to be in duplicate in order to insure reliable operation) is undesirable.

In order that small plants may have the benefit of scientific lubrication there has been recently designed and is now manufactured an individual oiling system, which possesses the advantage that all the various pipes, receivers, filters, pumps, etc., can be located on or close to the engine.

While undoubtedly every engineer appreciates the advantages of continuous-stream lubrication for bearings, it is probable that one reason they have not come into more general use is due to the fact that if an engineer is to equip his engine with a lubrication system he is forced to go into the open market and purchase his filters, pumps, piping, gang oilers, sight feeds, etc., independently.

That is, he has to practically design



RICHARDSON INDIVIDUAL OILING AND FILTERING SYSTEM APPLIED TO A SIMPLE CORLISS ENGINE his own system and then purchase the various elements and so attach them to his engine that all will work together. The engineer is not always conversant with the best method of piping up such a system; neither does he have a definite idea as to how much oil should be circulated through an engine of a given horse-power per hour and the size of filter and pump necessary.

To obviate these difficulties and to make it easier for the engineer to equip his engines with automatic lubrication, the individual Automatic Oiling System has now been further perfected, so that they need only know the horse-power of the engine, the type and make, and they can supply a system complete with all the necessary appurtenances, which can be readily attached to the engine by any ordinary mechanic.

By experimenting and carefully studying the standard designs of engines turned out by the different engine manufacturers of the country, the Richardson-Phenix Company has perfected this individual oiling system to such a point that any engineer will have very little difficulty in putting the system together and having it operate satisfactorily.

This company are now building two standard systems. The one shown in Fig. 1, known as the Richardson system, is more desirable for large Corliss engines, and is furnished in units for lubricating engines of 100-1,500 horse-power, and in sizes having an oil filtering capacity of from 4 to 35 gallons per hour.

The other, known as the Phenix system, is built for engines of from 10 to 200 horse-power, and in sizes having a filtering capacity of from 1 to 4 gallons per hour. This second system is illustrated in Fig. 2.

While the essential parts of these two systems are identical, they differ somewhat in detail. Briefly, their operation is as follows: Used oil from the various points of lubrication is collected in a suitable receptacle located at some point so that the oil flows into it by gravity; then a pump elevates the dirty oil to the top of the filter. After having all impurities and entrained water removed in the filter the oil either flows by gravity or is forced by a pump to the various points of lubrication.

At each point of lubrication a sight-feed oiler is provided, by means of which the amount of oil fed to that bearing can be accurately adjusted independent of the amount of oil supplied to all of the other bear-

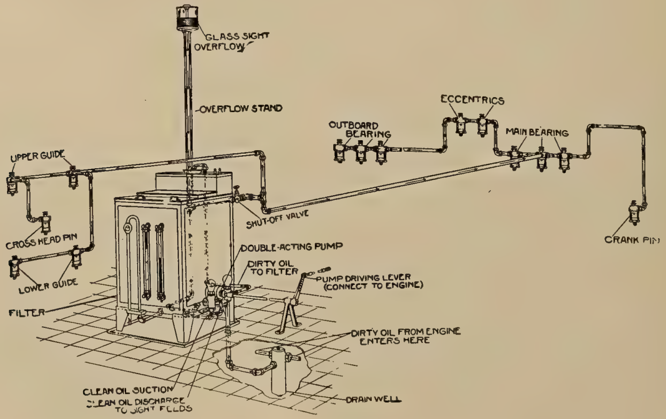


FIG. 1.—APPARATUS NECESSARY FOR A RICHARDSON OILING AND FILTERING SYSTEM FOR AN ENGINE HAVING 14 POINTS OF LUBRICATION.

ings. The gauge glass in each feed enables the attendant to see exactly how much oil is being fed.

These *individual* systems are designed as a unit—that is, all parts fit in together and operate satisfactorily. The filter and pump have the right capacity for the number of feeds, and the proper amount of piping is supplied for each type of engine. In connecting up the Richardson-Phenix systems all troublesome pipe fitting is eliminated by the use of novel devices known as "Union Cinch Fittings."

It is claimed that these systems will reduce the steam consumption of engines by 2 to 20 per cent. over that necessary when the old-fashioned hand-oiling method is relied upon. It has been figured out that in any size engine a reduction of 2 per cent. in the steam consumption, due to the reduction of power-consuming friction, will pay for necessary oiling systems in the amount of steam saved alone inside of one year. It is also claimed that these systems will reduce the oil consumption anywhere from 40 to 75 per cent. Further information on these two new-type systems can be had by addressing the Richardson-Phenix Company at Milwaukee, Wis.

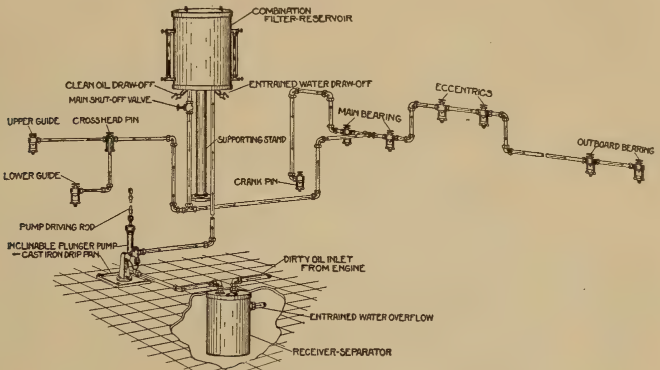


FIG. 2.—DIAGRAMMATICAL DRAWING OF PHENIX INDIVIDUAL OILING AND FILTERING SYSTEM, SHOWING APPARATUS AND MATERIAL NECESSARY FOR AN ENGINE HAVING 10 POINTS OF LUBRICATION.

**An Interesting Turbine Installation**

An interesting installation of turbines of medium and small capacity is that of the Kokomo Public Utility Company, Kokomo, Ind. This company has ordered from the Westinghouse Machine Company, East Pittsburg, Pa., one 1,200-kilowatt, one 60 horse-power and one 35 horse-power steam turbines as an addition to their present plant. The 1,200-kilowatt turbine is one of the well-known Westinghouse bleeder type, and an interesting point in connection with the installation is that an exhaust steam heating system is to be used in connection with this turbine. These turbines operate at a steam pressure of 160 pounds and under 28 inches of vacuum, obtained by means of a Westinghouse-LeBlanc condenser. The boilers are of the water-tube type, and consist of two units of 500 horse-power each, being supplied with injection water at 75 degrees Fahr., Indiana slack coal being used as the fuel.

The previous equipment consists of two 1,000-kilowatt Allis-Chalmers turbines, delivering two-phase, 60-cycle current at 2,300 volts, and the new equipment is intended to supplement this.

# THE LATEST CATALOGUES

### Power Transmission Machinery

Under the above title there has just been issued one of the most complete and up-to-date power and transmission catalogues that has been our good fortune to receive.

The work is well printed and illustrated, and is exceedingly rich in both technical and real information, and, while a large number of subjects are covered, the matter has been so condensed and arranged that it is bound to prove of the utmost value to the engineer in charge of an industrial plant, a mine, mill or large factory, where the question of power transmission is so important.

This work is issued by the Jeffrey Manufacturing Company, of Columbus, Ohio, and contains descriptive matter on the Horse-Powers of Steel Shafting, Standard Methods of Key Seating, sizes and dimensions of couplings, hangers, pillow blocks, countershafts, belt-tighteners, clutches and quills. A complete line of wood split pulleys and very complete description and information on rope driving are shown. A feature is made of the Jeffrey improved split iron pulley and the Jeffrey gears, including spur, bevel, miter, angle, reduction and angle miter.

In addition to descriptions of the well-known and largely-used line of power transmission machinery manufactured by the Jeffrey Manufacturing Company, the book contains many valuable tables on the horse-power of belts, method of calculating, bending and torsional moments for shafts, and other information which will prove invaluable to the engineering fraternity.

The book will prove a welcome addition to the library of any engineer; copy may be obtained by writing the Jeffrey Manufacturing Company and mentioning this magazine.

Ingersoll-Rand Company, 11 Broadway, New York City. Catalogue Form 4003. Bulletin of 16 pages on "Little Giant" Rock Drills. Catalogue shows machine in section, and gives views of machines at work on Panama Canal, etc. The distinctive characteristic of this tappet rock drill is the positive character of its valve movement. There being direct mechanical connection between valve and drill piston when steam or air is admitted to the cylinder, the piston *must* move; and when the piston moves the valve *must* be thrown, so that the operation of the drill is a certainty. The valve movement consists of three pieces—a valve, a rocker and a rocker pin. The rocker turns on the rocker pin, and is so arranged that one or the other of its lower members is always in contact with the piston. Its upper member, ending in a globular shape, projects into the valve. When the piston moves, a curved surface slides under one of the rocker contacts, pushing the rocker upward and swinging the valve in the same direction as the piston is moving. On the reverse travel of the piston this series of movements is exactly reversed. The throw of the valve covers and uncovers the supply and exhaust ports. Catalogue gives descriptive table of "Little Giant" drills, showing sizes and principal dimensions.

---

### Spray Nozzles for Re-cooling Condensing Water

The Schutte & Koerting Company, of Philadelphia, Pa., recently issued a new catalogue descriptive of their centrifugal spray nozzles for re-cooling condensing water. It is claimed that this is the simplest, most efficient and most economical method for this purpose yet devised, other advantages stated being low first cost and great durability. Views are given showing the installation of their spray nozzles at several large plants. A copy may be obtained by addressing them.

### Battery Truck Crane

This new machine is a short, heavy, storage-battery vehicle having mounted on its forward end a swinging crane, the hook of which is raised and lowered by a 1-ton hoist operated from the vehicle battery.

The vehicle is used in loading, hauling and unloading trailers, loading and unloading cars, hoisting and carrying on the hook boxes or barrels, and for stacking. The running of the vehicle, hoisting and carrying are controlled by one man.

The crane is equipped with special attachments to suit the carrying on of the work contemplated, and the height can be made to suit local conditions.

This new piece of apparatus has just been placed on the market by the General Electric Company, and is described in Bulletin No. 4892, recently issued. This bulletin contains illustrations of the truck and crane in use, and describes also various pieces of apparatus used in connection with it.

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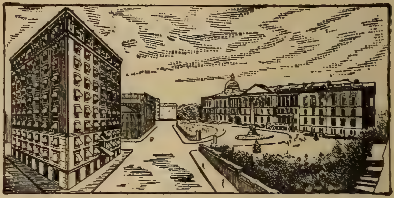

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